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1916.

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THE ASSOCIATION was organized in Boston, Mass., on June 21, 1882, with the object of providing its members with means of social intercourse and for the exchange of knowledge pertaining to the construction and management of water works. From an original membership of only TWENTY-SEVEN, its growth has prospered until now it includes the names of over **900** men. Its membership is divided into two principal classes, viz.: MEMBERS and ASSOCIATES. Members are divided into two classes, viz.: RESIDENT and NON-RESIDENT, — the former comprising those residing within the limits of New England, while the latter class includes those residing elsewhere. The INITIATION fee for the former class is FIVE dollars; for the latter, THREE dollars. The annual dues for both classes of Active membership are THREE dollars. Associate membership is open to firms or agents of firms engaged in dealing in water-works supplies. The initiation fee for Associate membership is TEN dollars, and the annual dues FIFTEEN dollars. This Association has six regular meetings each year, all of which, except the annual convention in September, are held in Boston.

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WILLIAM F. SULLIVAN,
President New England Water Works Association,
1916.

New England Water Works Association.

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This Association, as a body, is not responsible for the statements or opinions of any of its members.

LEAKAGE FROM LEAD JOINTS IN CAST-IRON WATER PIPES.

BY ARTHUR H. SMITH, ENGINEER ASSOCIATED FACTORY MUTUAL FIRE INSURANCE COMPANIES, BOSTON, MASS.

[*Read September 7, 1915.*]

This subject deals with one phase of a "conservation" movement which has for years received careful consideration by many officials and engineers who are responsible for the security and distribution of our public water supplies. During the last few exceedingly dry years prior to the present season, when the margin between available supply and consumption has been rapidly narrowing, special attention has been given to the elimination of waste as a means of increasing this margin. Many towns and cities have found that by systematically reducing the amount of water running to waste, their present supplies could be made ample for their needs. By various systems of metering mains, large leaks have been located and repaired, the installation of meters on house connections has largely stopped unnecessary losses taking place at plumbing fixtures, and appreciable savings have been made. With the development of the pitometer into practicable form, additional impetus has been given to the locating of leaks in mains, and extensive surveys have been made in New York, Philadelphia, Washington, Chicago, Milwaukee, and other cities, the results of which are matters of record.

The studies made have shown very large losses from three principal causes:

(a) Leaking of underground mains.
(b) Broken or abandoned service pipes.
(c) Defective plumbing fixtures.

Of these causes, the third is being corrected quite satisfactorily by metering. The first and second are more difficult to reach. In old systems it frequently happens that large leaks occurring in porous soil, under streams or near sewers, may continue for years without giving any surface indications and thus escape the attention of the unthinking or careless official. Usually it is feasible at some labor and expense to locate and stop these larger wastes, but the smaller leaks occurring at imperfectly made lead joints or at minute cracks in the pipe represent a class of losses generally felt to be incurable. It is more especially with these types of leakage and some observations regarding the amount lost in this way that this paper deals. They rarely cause much concern to the water-works man, although the total volume lost in a year is often very large.

In an effort to determine the volume of leakage from underground mains, some officials have simply subtracted the quantities taken out from those fed into a system, but this has generally not been very successful because of the large number of assumptions or guesses which have to be made. Of course no conclusions, even approximately correct, are possible except where practically 100 per cent. of the service supplied is metered. The best performance along this line which has come to the writer's attention is that in the city of Cleveland, Ohio, where, under the administration of Dr. E. W. Bemis, in 1909, all but 7 per cent. of the supply delivered into the mains was accounted for, a loss equal to only 6.3 gal. per capita per day. The same year the water registrar of Worcester, Mass., reported that all but 19 per cent. or 11.5 gal. per capita of the supplies metered into the mains of that city was accounted for. In the several suburban communities of the Metropolitan District surrounding the city of Boston which are 100 per cent. metered, about 65 per cent. of the supplies entering the systems is metered out or otherwise accounted for. In 1904 Mr. Dexter Brackett, C.E., reported* quite in detail the various forms of waste which were taking place in the city of

*JOURNAL N. E. W. W. A., XVIII, 107 (1904).

Boston and its suburbs. His general conclusion was that from 10 000 to 15 000 gal. per day per mile of pipe were being lost by leakage from the underground mains, which represents a total for the districts served of 15 to 22½ million gallons per day, or 16½ to 25 gal. per capita per day. An interesting suggestion contained in that report as a help in reducing this leakage is that meters of Venturi or Deacon type be installed at favorable points on the city mains so that frequent determinations of losses may be made in prescribed sections.

The general experience of water-works men who have studied this particular phase of leakage seems to be that from 30 to 40 per cent. of the total supply which enters the system is unaccounted for. That is, only 60 to 70 per cent. is delivered for legitimate purposes, the rest being lost as leakage.

In an attempt to determine with some accuracy what is a proper allowance for this incurable waste, Mr. John R. Freeman secured data from several New England cities for his report on the " Water Supply for the City of New York," dated March, 1900, to show the consumption during early morning hours, which was assumed to be made up largely of leakage from mains. On a "gallons per capita per day" basis, these figures were: Fall River, 10; Woonsocket, 8; Boston, 10; Providence, 20; Milton, Mass., 3.

It is not correct to assume that all of the leakage in the instances cited takes place at lead joints and cracked pipe, for there is an appreciable contribution from defective service pipes, hydrant valves, blow-off gates, leaky packing at gate valve stems, etc. While, therefore, the " gallons per capita per day " basis is well adapted to represent the total underground leakage, a more appropriate unit in which to express the leakage at joints seems to be "gallons per day per linear foot of lead joint," and in the cases quoted below, this standard has been used.

In the writer's experience with the Factory Mutual Fire Insurance Companies, questions have frequently arisen between the managers of corporations insured by them and public water-works officials as to what becomes of the water passing from public mains into private fire protection yard systems. In such cases the water-works official is usually well satisfied to install a meter on the main feeder and charge the consumer with the registered

quantity of water, allowing him to use it for whatever purpose he desires, while the attitude of the insurance companies has been that if all domestic and manufacturing water is used from a separate metered line, the interests of the community are not jeopardized by omitting meters from the fire service lines, provided, of course, that these are used solely for this purpose. In other words, the water for extinguishing fire in protected plants should be as freely supplied and with as little obstruction to flow as it would be if taken from street fire hydrants. The arguments on both sides of this proposition are so well known that they will not be repeated.

In one instance, at a risk in Eastern Massachusetts having both high and low service connections with public mains, it was found that considerable quantities of water were escaping from the high-service reservoir, and as this occurred during a dry season when there was a natural shortage of supply, the waterworks officials deemed it expedient to shut off this particular connection, which they did without notification to the corporation. In the study of the situation which followed, the writer found that 11 000 gal. per day were being lost through the underground system, thus representing about 7.3 gal. per day per linear foot of the 1 500 ft. of lead joint involved. As this was deemed excessive, the points of greatest loss were approximately located by meter readings on the various sections into which the system was divided by gate valves, the joints were uncovered in the worst sections, and those found leaking were repaired. By this means, the loss was reduced to about 2 000 gal. per day, or 1.3 gal. per linear foot of joint. The pipes in this instance were 6 in. and 8 in. in diameter, total length 5 500 ft., length of lead joint 1 500 ft., and average pressure 105 lb.

A short time after this experience, a favorable opportunity came for conducting a test for leakage on a small new public waterworks system at Medway, Mass. This work was built by the Hanscom Construction Company of Boston, H. A. Symonds engineer, under the supervision of Mr. Erastus Worthington, C.E., of Dedham, Mass. The sources of supply are driven wells from which water is pumped through the distribution system to a standpipe 30 ft. in diameter by 80 ft. high, whose capacity per foot in height is thus 5 288 gal.

The distribution system is made up of cast-iron pipes 6 in. to 12 in. in diameter, Class E, New England Water Works Association specifications. The lead in the 6-in. sockets is 2 in. deep, and in the 8-in., 10-in., and 12-in. sockets 2½ in. deep. In the following table, the system is analyzed with respect to the lead joints.

TABLE 1.

Cast-Iron Pipe.		Number of Lead Joints.						Linear Feet of Lead Joint.		
		Straight Pipe.								
Size. Inches.	Linear Feet Laid.	12-Ft. Lengths.	Short Lengths.	Specials.	Gates.	Hydrants.	Total.	Per Joint.	Total.	Per Foot of Pipe Laid.
12	3 279	274	3	34	5	...	316	3.56	1 124	0.34
10	11 498	958	5	63	9	...	1 035	3.01	3 116	0.27
8	10 471	873	6	45	9	...	933	2.48	2 309	0.21
6	34 761	2 897	40	308	61	107	3 413	1.91	6 519	0.19
4	645	54	1	6	2	...	63	1.36	86	0.13
	60 654						5 760		13 154	

At the time of the test the system had been entirely completed with the exception of service connections, none of which, however, had been put in. The mains and standpipe had been filled about ten days previously and the hydrants had been thoroughly flushed out, thus removing most of the air. With the standpipe again filled and with pumps stopped, the observation for leakage was made for a twenty-four-hour period by simply noting the rate of lowering of the water level. During this time, the static pressure at hydrants in all parts of the town was found to vary from 37 lb. to 99 lb., and to average for the entire system about 75 lb. A careful inspection of the entire route of the pipes revealed no evidence of large leakage, and it is believed that practically all was at lead joints.

The total loss in twenty-four hours was found to be 22 400 gal., which, corrected for small known drafts and a slight leak in the standpipe, showed a net loss taking place in the underground mains of 20 800 gal. Reducing this to the unit by dividing by 13 154 gives 1.58 gal. per day per linear foot of lead joint, an

equivalent of 9 gal. per capita of the population on the pipe lines. The possible errors in determining ought not to exceed 5 per cent., so that the correct figures for this case should lie between 1.50 and 1.65 gal. per day per linear foot of lead joint. As the construction work was carried out under good average conditions by reputable contractors, employing experienced pipe layers, joint makers and calkers, without the expectation that it was to be tested, it is felt that the results are fairly representative for the size of pipe and class of work.

The following table contains a list of cases, believed to be accurately reported, where similar determinations have been made, and it is presented here for comparison.

This table shows what general experience confirms, that bottle tightness in lead joints of cast-iron water mains is an impossibility. So long as pipe lines are built in this way, and from our present knowledge there seems no better method for general practice, leakage must be reckoned with. The problem, then, is to reduce it to a minimum. In this endeavor two general lines of action are possible: first, the substitution of some more satisfactory material for lead; second, an improvement in the design and construction of the lead joint. Under the first heading there has already been produced a substance called "Leadite" which has been quite extensively used. Whether this will solve the leakage problem and become the universally recommended material for cast-iron pipe joints is still an open question. Under the second heading, a general stiffening of specifications under which pipe is laid, with more careful supervision of joint making, laying in deeper trenches to reduce expansion and contraction, mechanical injury, etc., and rigid tests for leakage after completion would have a tendency to produce tighter work.

The standard of tightness which is to be regarded as acceptable will be subject to much difference of opinion depending upon the point of view. The *seven* gallons per day per linear foot of joint reported by the Metropolitan Water Board as leaking on one section of 20-in. main seems to the writer to be much in excess of a reasonable performance, and no doubt in that case leaks were discovered by the test and afterwards repaired. At this rate a 12-in. main would lose 25 gal. and a 20-in. main 43 gal. per day at

TABLE 2.

System.	Pipe Sizes. Inches.	Pipe Length. Feet.	Pressure. Pounds.	Leakage. (Gallons per Day per Linear Foot Lead Joint.)	Remarks.	Reported by
Providence High Service...	16	29 400	114	0.22	Three years old.	J. R. Freeman, C.E.
Milton, Mass., water-works system	4 to 12	16 900	85	1.30	Ten years old.	J. R. Freeman, C.E.
Nine small water-works systems................	6 and 8	....	50	0.47	New	J. R. Freeman and C. F. Loweth, C.E.
Metropolitan Water Works, Boston................	60	8 220	66	0.90	New	Dexter Brackett, C.E.
	48	116 563	50–150	3.16	New	
	42	11 744	50–150	2.43	New	
	36	25 663	50–150	3.19	New	
	30	7 287	50–150	0.81	New	
	24	20 553	50–150	3.44	New	
	20	40 231	50–150	7.00	New	
	16	49 903	50–150	4.65	New	
Plymouth Cordage Co......	6 to 10	11 780	60	2.00	Fire protection system (old).	J. H. Damon, Chief Engineer.
Hamilton Woolen Co.......	6 and 8	5 500	105	7.30	Fire protection system before repairs.	A. H. Smith.
Hamilton Woolen Co.......	....	....	....	1.30	Same after repairs.	A. H. Smith.
Medway, Mass., Water Works......	6 to 12	60 654	75	1.58	New	A. H. Smith.

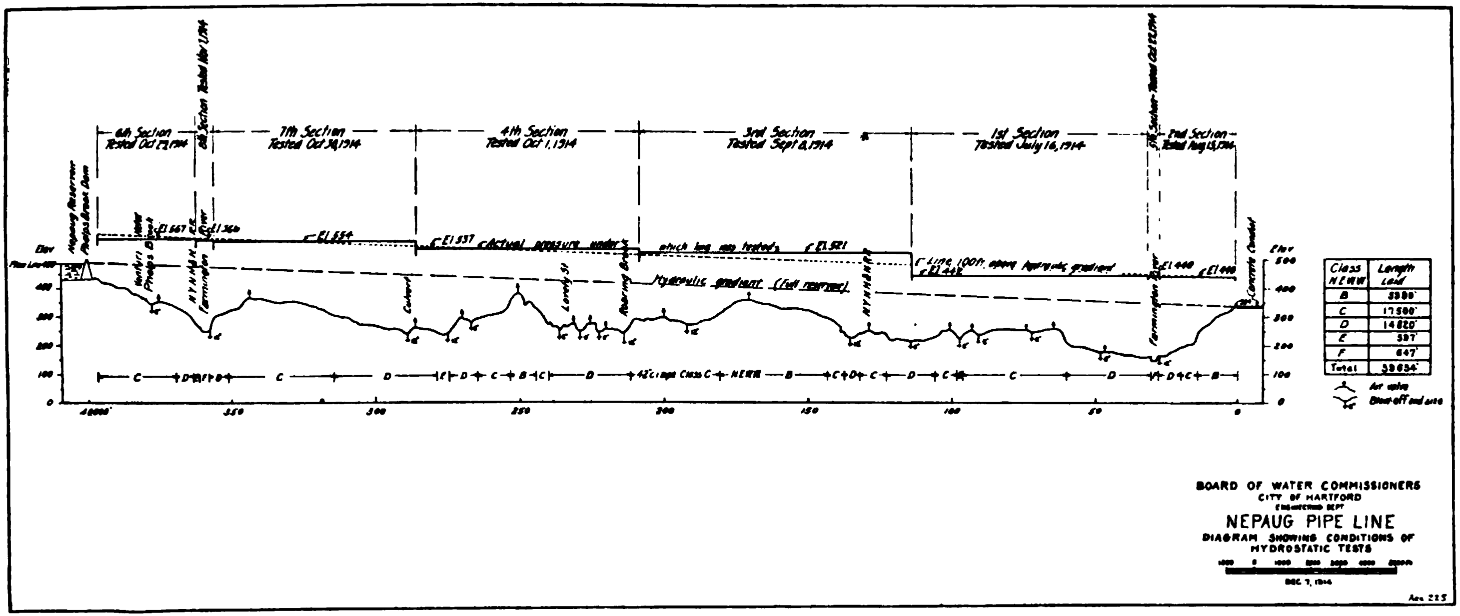

BOARD OF WATER COMMISSIONERS
CITY OF HARTFORD
NEPAUG PIPE LINE
DIAGRAM SHOWING CONDITIONS OF HYDROSTATIC TESTS
DEC. 7, 1914
6th Section Tested Oct 29, 1914
7th Section Tested Oct 30, 1914
4th Section Tested Oct 1, 1914
3rd Section Tested Sept 8, 1914
1st Section Tested July 16, 1914
2nd Section Tested Aug 13, 1914
Hydraulic gradient (full reservoir)
Actual pressure under which line was tested
Nepaug Reservoir
Phelps Brook Dam
Farmington River
Roaring Brook
Culvert
Concrete Conduit
Class NEWW | Length Laid
B | 3980'
C | 17580'
D | 14820'
E | 597'
F | 647'
Total | 39634'
Air valve
Blow-off and gate

Fig. 1.

each joint. On the other extreme shown in the table probably few jobs can equal the record on the Providence High Service of 0.22 gal. per linear foot of joint.

If leakage on new work can be limited to *one* gallon per day per foot of joint under 100-lb. pressure, the performance can be called good and acceptable. It would seem that below this limit, thought and energy might better be expended in tracing other forms of waste than that at lead joints.

DISCUSSION.

MR. C. M. SAVILLE * (*by letter*). The following tables show the conditions and the results of the tests on about 7.5 miles of 42-in. cast-iron supply main for the city of Hartford, laid in 1913–14.

The clause in the specification relating to the testing was:

"*Hydrostatic Test.*

"SECTION 6. 12. The pipe shall be tested in sections of ordered or approved lengths under a static pressure corresponding to a water level everywhere at least 100 ft. above the hydraulic gradient shown on Sheet 2 of the contract drawings. All visible leaks shall be stopped, and the entire leakage from any section under such pressure shall not exceed a rate of 2 gallons in twenty-four hours per linear foot of pipe joint, the length of joint to be figured on the nominal interior diameter of the pipe. Should the leakage exceed this amount, the joints shall be recalked until the leakage under the above pressure is within the limit prescribed. The test pressure shall be maintained for at least twenty minutes. For these tests the contractor shall provide clean water, suitable bulkheads, and all necessary pumps, piping, connections, meters, gages, and other equipment without extra compensation."

MR. GEORGE H. FINNERAN.† I should like to know how many of the water works represented here test main-pipe joints for leakage before back-filling the trench. I know that as a matter of theory such a course ought to be followed, but as a matter of practice I should like to know to what extent such tests are made. In Bos-

* Chief Engineer, Board of Water Commissioners, Hartford, Conn.

† Assistant Superintendent, Water Works, Boston.

SUMMARY OF HYDROSTATIC TESTS OF SECTIONS OF NEPAUG PIPE LINE.

Date Tested.	Data.					
	Section.	Station to Station.	Length.	Number and Size of Joints.	Total Lin. Ft. of Joint, Using Actual Length of Lead Joint as if of Class D Pipe.	Total Lin. Ft. of Joint Based on Nominal Diameters.
1	2	3	4	5	6	7
Aug. 15, 1914	Transition to lower river crossing.	0+79 — 27+85	2 646	223 — 42 in. 2 — 12 in.	2 636	2 459
Oct. 22, 1914	Lower river crossing.	27+38 — 31+21	383	38 — 42 in.	448	418
July 16, 1914	Lower river crossing to Wallace's Swamp.	31+43 — 113+91	8 248	694 — 42 in. 8 — 6 in.	8 193	7 647
Sept. 8, 1914	Wallace's Swamp to Roaring Brook.	114+24 — 208+54	9 430	798 — 42 in. 6 — 12 in. 2 — 6 in.	9 430	8 800
Oct. 1, 1914	Roaring Brook to Culvert near Camp 1.	208+59 — 285+88	7 729	659 — 42 in. 6 — 12 in. 8 — 6 in.	7 800	7 281
Oct. 30, 1914	Culvert near Camp 1 to upper river crossing.	285+98 — 356+12	7 014	592 — 42 in. 2 — 12 in.	6 990	6 518
Nov. 7, 1914	Upper river crossing.	356+18 — 361+93	575	56 — 42 in. 2 — 12 in.	666	622
Oct. 29, 1914	Upper river crossing to end of line at Phelps Brook Dam.	362+05 — 397+15	3 510	301 — 42 in. 2 — 6 in. 2 — 12 in.	3 560	3 320
		Totals	39 535	3 361 — 42 in. 20 — 12 in. 20 — 6 in.	39 723	37 065

Summary of Hydrostatic Tests of Sections of Nepaug Pipe Line. — *Continued.*

Date Tested.	Section.	Results from Tests.				Deductions. Rate of Leakage. Gals. per 24 Hours.			
		Test Pressure.	Total Leakage Gallons in 20 Min.		Per Cent. Actual to Allowable.	Total.	Per Lin. Ft. of Pipe Joint on Basis of Col. 6.	Per Lin. Ft. of Pipe Joint on Basis of Col. 7.	Per Inch-Mile of Pipe, Basis of Col. 7.
			Allowable*.	Actual.					
		8	9	10	11	12	13	14	15
Aug. 15, 1914	Transition to lower river crossing.	120 lb. at Sta. 27+25	68.3	33.7	49	2 426	0.920	0.987	115.0
Oct. 22, 1914	Lower river crossing.	120 lb. at Sta. 27+38	11.61	12.50	108	900	2.01	2.15	295.0
July 16, 1914	Lower river crossing to Wallace's Swamp.	120 lb. at Sta. 31+43	212.5	29.9	14	2 153	0.262	0.281	32.8
Sept. 8, 1914	Wallace's Swamp to Roaring Brook.	99 lb. at Sta. 208+54	244.6	83.0	34	5 976	0.633	0.679	79.6
Oct. 1, 1914	Roaring Brook to Culvert near Camp 1.	120 lb. at Sta. 285+88	202.2	197.5	98	14 220	1.82	1.95	231.0
Oct. 30, 1914	Culvert near Camp 1 to upper river crossing.	127 lb. at Sta. 285+98	181.0	0.75	0.4	54	.0077	.0083	0.97
Nov. 7, 1914	Upper river crossing.	135 lb. at Sta. 361+93	17.28	9.13	53	657	0.986	1.06	144.0
Oct. 29, 1914	Upper river crossing to end of line at Phelps Brook Dam.	129 lb. at Sta. 362+05	92.2	16.9	18	1 217	0.342	0.367	43.6
		Totals	1 030	383.38	37.2	27 603	0.695	0.745	87.9

Note. — Total length of pipe line from Sta. 6+79 to Sta. 397+15=39 636 ft. The difference between this and the total length tested is due to the untested closure pieces and several untested lengths at Wallace's Swamp and at the lower river crossing.

* Two gallons per linear-foot pipe joint, based on nominal diameter.

ton we do not make them. I am curious to know if there are any cities or towns wherein the practice is carried on religiously, without deviation or exception.

MR. FRANK L. FULLER.* It has always seemed to me very important to test water-pipe systems. On the completion of the Winchendon, Arlington, and Uxbridge systems, this was done by means of a boiler testing pump. This pump has a very small piston or plunger and of course throws very little water, perhaps three gallons per minute. The pump has a lever handle and a stroke about six inches long, and a pressure of two to three hundred pounds per square inch can easily be obtained.

After the pipe system has been filled with water, gates are shut so as to form a closed section of moderate size. The discharge from the pump is connected to a hydrant within this section and the suction to a tight barrel or cask. If the pipe within the section shut off by gates is free from leaks, the pressure can be quickly raised to any desired point. If upon shutting the gates the pressure falls and cannot be raised by working the pump, there is a leak within the section greater than the capacity of the pump. If the reservoir or standpipe pressure does not force the leakage to the surface, so that the leak can be found, some other method must be employed. One method is, with a larger pump to force into the closed section, under sufficient pressure, an amount of water larger than that escaping through the leak. If the trouble comes from a cracked pipe or a poor joint, the increased pressure is likely to still further open the split pipe or the poor joint, and water show upon the surface of the ground.

MR. WALTER E. SPEAR.† The Board of Water Supply has laid no pipe in the main conduit lines smaller than 48 in. For these lines our specifications require the leakage to come within a maximum of two gallons per day per foot of joint. The actual measured leakage ranged from this figure down to less than half this amount.

PRESIDENT METCALF. Do you test them, as a matter of fact, before the pipe is covered?

MR. SPEAR. Hydrostatic tests were generally made on sections

* Civil Engineer, Boston.

† Department Engineer, Board of Water Supply, New York.

between line valves of about half a mile in length, and ordinarily after the pipe was covered. The tightness of the pipe seemed to be largely a question of supervision and the reliability of the workmen. The best results were noted on a job where the contractor had calkers whom he knew and could rely upon. In one organization every joint was marked to identify the workman who calked it, and when any leakage occurred the calker responsible for it was brought to account. We had one line on which a great deal of recalking had to be done because the contractor did not have proper supervision and did not know his calkers.

MR. S. E. KILLAM.* As far as the Metropolitan water supply is concerned, the test for leakage on these lines was made as soon as the contract was completed and before the final payment. This is true of all recent contracts with one exception, and that is on a line that was just completed, where it was impossible to test until a parallel line could be put in use.

I was surprised at the figures quoted in the paper just read, on the leakage of a 20-in. main of the Metropolitan Water Works. I think there must have been some leak of considerable size which was repaired before the line was finally put in use.

Last year a test on a 20-in. line 4 965 ft. in length showed a leakage of one gallon per minute, equivalent to .6 gal. per day for each foot of joint. On this line there were twelve joints made of wood staves, which are installed to reduce the amount of electricity traveling on the pipe line. The test was made in a closed trench, and after the line had been under pressure for about seven days. The pressure on this main varied from 35 to 100 lb.

A recent test of the 12-in. submerged line under the Neponset River in the Hyde Park district of Boston showed the line to be practically tight under 150 lb. pressure. The length of this line is 326 ft., of which 134 ft. is of the spherical joint type. This line was laid in 1902. The trench under the river was excavated with a dredge, and the pipe made up on the shore and buoyed across on empty oil barrels, after which the barrel lashings were cut, allowing it to settle into the trench. Under the direction of the State Board of Health, the river channel during the last few years has been deepened and improved for the purpose of draining the great

* Superintendent of Pipe Lines, Metropolitan Water Works, Boston.

area of wet meadows in the central part of the watershed. On August 16, 1915, a leak developed in the river channel, and on investigation it was found that the pipe had pulled apart, presumably by the dredge, which had been at work in this locality. The pipe was pulled into place and the lead recalked and the joint faced with lead wool. A test was then made, with the result given above.

MR. FINNERAN. While we in Boston know of various means and methods of testing sections of pipe lines, and upon occasion have employed them, the question that I should like to have answered is to what degree it is considered desirable to defer back-filling until the pipe joints have proved their tightness. In laying in congested city streets it is desirable to back-fill as quickly as possible, so as to inconvenience the public as little as possible; and it is for that reason more than any other that in Boston we omit the testing before the trench is back-filled. As I said before, we do in many cases test for leakage, but we have no means of knowing which particular joint, if any, is leaking. That can be ascertained in a practical manner only by observation.

MR. MORRIS KNOWLES.* In Pittsburg the practice is to know that the pipes are tight before back-filling.

MR. IRVING S. WOOD.† In Providence the work is all done by the city, and pretty thoroughly inspected. It is not the practice to test the joints before back-filling.

MR. A. E. MARTIN.‡ In Springfield we seldom test the pipes before back-filling.

In the outlying districts it might be possible and practical to test them, but in the main streets of the city where the travel is very congested it would not be practical nor possible.

MR. GEORGE A. STACY.§ As far as practical, we like to test the joints before they are covered. We rely a good deal upon a good man with plenty of time to do the work properly, and rely something on the nature of the soil to detect a leak that would amount to anything. The soil being a hard, compact clay, we cannot lose a great deal of water without its coming to the surface. Our con-

* Civil Engineer, Pittsburg, Pa.
† City Engineer's Office, Providence, R. I.
‡ Superintendent of Water Works, Springfield, Mass.
§ Superintendent of Water Works, Marlboro, Mass.

sumption according to the pumping record is such that we think perhaps ignorantly that we have got a very small percentage of leakage. We have not gone into it in a scientific way.

The question comes to my mind that after you have tested your pipe lines, are they going to stay tight under what might be called working conditions; that is, unequal settlement, water hammer, etc.? Are all those joints going to show the same results five or six years afterward as they do at the time they are tested?

I have a 16-in. force main two miles long that is under a pressure of from 60 to 182 lb., and it never showed any leaks until seven or eight years after it was laid. Since then we have had five or six leaks, these extended over ten or twelve years, all would be called small leaks, and were easily stopped. We had one recently down near the pumping station, where our greatest pressure is; the pipe had been in there twenty years and never caused trouble. The lead had started out and it was some work to drive it back as we did not shut the water off. We have had no trouble with it since. In laying this line we crossed a brook, where, unfortunately, the clay jointer gave way, and they had to pour the joint two or three times. We expected trouble here and we have watched that joint twenty years but have never found any. I think that joint is as good as any in the line. I think it is a proper thing, and I guess we all agree on that, when it is practical, to test all our joints before they are covered. I have just laid a short line, or am laying it, with Leadite. We left three or four joints to see how they looked when we turned the water on, but all we ever found was a little froth, and the next morning that was gone, and the joints tight, and they seemed to grow tighter as they grew older; why, I don't know. If the Leadite is as durable as the pipe, I do not know why these joints should not remain tight during the life of the pipe. I have one or two joints that I made with Leadite about five years ago. We have kept an eye on them, especially one joint where the Leadite was at the wrong temperature. That joint leaked a drop or two. We dug down to that before the season closed and found it absolutely tight. The only leak that did not stop that I have had in using Leadite is where we had a little water in the joint. I found there that I did not know how to make Leadite tight on a wet joint. I suppose that might be overcome, but I think if I

had one that was pretty wet I should use lead or lead wool in making the joint.

A MEMBER. There is one point I have not heard any one mention. Some years ago I was laying a line of pipe up to a spring which was to supply a small town. There were no streets to be crossed, so we left the trench open to test the joints, and the pipe was exposed for quite a while. The water ran in; a few joints sweated and we calked them. The contractor had his men all busy at another part of the line by that time and he did not want to bring them down to back-fill, so we let the pipe lie open. It was in the fall with cool nights and hot weather in the daytime, and we found that every day the pipes expanded and every night they contracted, and in the morning we would find sweaty joints.

MR. GEORGE F. MERRILL.* It brings to my mind an experience we have had at Greenfield. We have a line between our reservoirs, that is left uncovered, subject to the temperature changes. I find those joints after they are calked quite often get to leaking — I suppose because of the temperature, the expansion and contraction. I presume that would work more or less on a line where the trench was left open for a long time.

MR. FRANK L. FULLER. While it is perfectly feasible to test an extension to an old system before back-filling is done on a line of pipe, I think it is true that in the majority of the country systems the pipe is often laid before there is any possibility of testing it. That is, the pipe laying may be the first thing that is done, and the installing of the pump and the completion of the reservoir is the very last part of the work, so there is no opportunity to test the pipe line until after it is back-filled.

MR. W. C. HAWLEY.† There is one fact which I think we should keep in mind in considering this question of leakage. It has been customary to compute leakage on a rate per linear inch of joint or per inch-mile of pipe. Is this the proper basis for comparison? As a matter of fact, the great bulk of leakage is not caused by a general leakage from every or even many joints. My experience, and I have seen many miles of pipe uncovered for the purpose of replacement with larger pipe or for tapping, has convinced me that a very

* Superintendent of Water Works, Greenfield, Mass.

† Superintendent of Water Works, Wilkinsburg, Pa.

large percentage of joints are absolutely tight. Most of the leakage is caused by a few large leaks; some is from stuffing boxes on gate valves, which obviously has no relation to diameter of pipe or length of joint. The frequent use of the pitometer on many water-works systems seems to confirm my contention. This instrument does not locate general leakage, but does find the large leaks. I mention this so that those who have not given the matter consideration will not conclude from our discussion that a general leakage is to be expected. I think that we should also consider carefully whether or not the basis which has been chosen for stating the amount of leakage is a desirable one or if a better one should be chosen.

We test every joint before it is back-filled, and if we cannot lay but half a dozen joints we put in a plug and run it with Leadite and test, cut out the plug in ten or fifteen minutes and go ahead.

In Atlantic City we used lead, and generally tested our pipes before back-filling.

MR. EDWARD D. ELDREDGE.* I do not put as much confidence in testing the pipe as in insuring a good foundation under the pipes. I think some large leaks occur where the pipe settles unduly, although under test, before filling, no leak may appear. In back-filling the trench the first process should be to ram the filling firmly under the pipe, to be sure that whatever results from the weight of back-filling, the pipe is going to maintain its position. Then if the calking is done in a first-class manner the probabilities are that the joints will be tight. In our system of about 15 miles of pipe, we do not know of any leakage. The town is principally a summer resort. The winter population is only five or six hundred. There have been days in the winter when the consumption was only 10-000 gal. That would indicate a very small leakage. We make sure that in back-filling no settlement of the pipe occurs. Sandy soil favors this operation.

MR. A. E. MARTIN. In following up what Mr. Hawley said, about the leakage not being from every joint, we had a little experience in that line during this last summer or early in the spring. On account of changes in grades of streets we had to re-lay and lower about a mile of 30-in. main, and in the whole length of that

* Superintendent of Water Works, Onset, Mass.

main we did not find half a dozen joints that were even sweating. The line was laid about 1892. I think it is safe to say that Mr. Hawley is right in that the leakage is not from every joint but generally from some few bad ones.

MR. SMITH. I am very glad this feature of the discussion has come up, because I think very likely my paper has given a false impression on that point. I know that what the gentlemen say is perfectly true, — it is not every lead joint that leaks. My own experience and that of many others with whom I have talked confirms this. The water commissioner of Worcester, Mass., once said to me, "We do not have any leaks in lead joints. We have a bottle-tight system. I have seen miles and miles of pipes with lead joints uncovered without a single leak," testimony which proves that at least some joints do not leak. There are however, many small leaks besides those large ones which Mr. Hawley has called attention to, and this paper was intended to emphasize this fact and to arrive at some more definite idea of the volume of leakage which must certainly be expected on every large cast-iron pipe system. Therefore it seems to me that the experience of these water-works men, if it can be formulated and got into shape, would establish just such a standard as I have been trying to set before you. The records are pretty meager and your accumulated experience would have great value in establishing a basis of judgment.

MR. WILLIAM F. SULLIVAN.* This discussion has brought out a lot of information regarding leaks on lead and Leadite joints. My own experience has been such that whenever the pressure was put on uncovered pipes, we have inspected the joints to see what leaks there were, if any. Occasionally we would find small leaks. Recalking or "touching up" the joints would stop any "weeping." On any pipe line that had been back-filled and that we had doubts about being tight, we would close the gates and by-pass one gate, setting a small meter on the by-pass and find out the extent of the leak. We periodically test a river crossing which we know leaks. It is a 24-in. pipe, 250 ft. long. At present the extent of leakage on this section of pipe is 164 gal. per day.

MR. GEORGE F. MERRILL. There is one point that has not

* Superintendent of Water Works, Nashua, N. H.

been brought out. Mr. Smith's paper is of great value and shows us what a new pipe line should be. There are, however, two elements of leakage, — one, underground leakage, and another, under-registration of meters. Where we have an old system the element from the under-registration of meters might mean quite a considerable amount.

[*Note.* Additional recent discussion of this subject will be found in JOURNAL N. E. W. W., XXVIII, 315 (1914), — "Allowable Leakage from Water Mains," by E. G. Bradbury.]

DECOLORIZATION OF WATER BY STORAGE.

BY RALPH H. STEARNS.

[*Read September 8, 1915.*]

It has been generally recognized that when the colored river waters of New England were stored in reservoirs for a considerable time a substantial reduction in color was effected. In connection with the improvement of the quality of the Sudbury River water, this subject was carefully studied under Mr. Desmond FitzGerald, chief engineer of the Boston Water Board, in the years 1891–1894, and the amount of the reduction in color by storage for certain of the Sudbury reservoirs was estimated. The subject "Decolorization of Water" was fully treated at an informal discussion before the American Society of Civil Engineers in 1901.*

The experience on the Sudbury watershed largely influenced the development of the Wachusett watershed, and resulted in the construction of a reservoir of extraordinary size and with a clean bed to eliminate the tastes and reduce the color of the water. Now that the records of the colors of the Wachusett reservoir water are available for a number of years, a further study of the reduction in color and its relation to storage has been made, and the results are herewith presented.

It must first be understood that the results apply to New England river waters, colored with a vegetable stain which originates largely in swamps, from the peat and decaying vegetable matter. There is generally only a very slight turbidity in the water, the sedimentation of which would have but a small effect on the color.

Iron plays a peculiar part as a coloring agent in reservoir water. A study of the relation of iron to color, made in Boston about 1892, revealed the following facts:

Where there is plenty of dissolved oxygen in the water, the iron is kept in its insoluble ferric state and is therefore precipitated

* Trans. Am. Soc. C. E., Vol. XLVI, p. 141.

and remains on the floor of the reservoir. When the oxygen in the water becomes exhausted, this ferric iron may be reduced to its ferrous state by the surrender of its oxygen to the organic matter, and may then be taken up by the water. A lack of oxygen often obtains during the warmer months at the bottom of deep reservoirs, below the plane reached by the circulation of the upper waters, where organic matter is abundantly supplied either by the bottom or the influent water. The colorless ferrous iron upon oxidation imparts a high color to the water, which is gradually reduced to normal again by precipitation of the iron. Iron has appeared on occasions in the Hopkinton and Borden Brook reservoirs, and frequently in Milham Brook, but not in the other reservoirs listed in the table.

In earlier discussions it has frequently been stated that the bleaching of water was due entirely to the agency of sunlight. That sunlight is a bleaching agent was conclusively proved by exposing colored waters in bottles to the sunlight, while similar samples were kept in the dark. The former were in time completely decolorized, while the latter were practically unchanged. Also, by placing bottled water at different depths in a reservoir, the effective bleaching was found to be confined to the upper few feet, while at a depth of 10 ft., in a reservoir water having a color of 40, no appreciable reduction was found after a month's exposure.

The conclusion that bleaching is the result of sunlight alone is, however, not borne out by the actual observations in deep reservoirs. In such reservoirs a complete mixing occurs in the early spring, after which the surface water becomes warmer and of less specific gravity than the lower waters, and vertical circulation between the upper and lower strata ceases entirely until the fall overturn occurs. In this bottom water, thus left stagnant and beyond the reach of sunlight, decolorization goes on, and at a considerable rate.

Taking, for example, the Wachusett records for 1907–1914, the maximum color reached at the dam after the spring overturn averaged 18.6, and this was reduced before the fall overturn to 14.4 at the bottom, as against 12.6 at the surface. In other words, the rate of reduction was about 30 per cent. less at the bottom.

At the Hopkinton and Ashland reservoirs, with their highly colored waters, the decolorization at the bottom appears to have been about one half of that at the surface. It may be urged that the reduction of color at the bottom is due to dilution by ground water, but this is of no such quantity near the dams as to dilute the water of these reservoirs even when drawing them down.

The only other explanation of decolorization at the bottom is slow oxidation without sunlight. As the dissolved oxygen in the water at the bottom of a stripped reservoir supplied with good water does not become exhausted, this seems the rational explanation. The failure of bottled water to bleach was probably due to lack of oxygen and insufficient time.

The decolorization of water by storage, then, is apparently pure bleaching, brought about by sunlight and by oxidation, and taking place at the bottom of deep reservoirs in cases where there is plenty of dissolved oxygen in the water as well as at the surface. The bleaching action, while always going on, is greatly accelerated during the summer months, and becomes a minimum when the reservoir is covered with ice.

It appears that the reduction in color is proportional to the initial color — that is, the percentage reduction is independent of the initial color. Also, it has been shown that decolorization will continue to completion, both in bottles and in large natural lakes.

The reservoirs which were studied, as seen in the table below, were mainly those of the Metropolitan Water Supply, but a few others were added where reliable records of influent and reservoir colors were available. The results are based on averages of from five to fifteen years, which tends to neutralize any anomaly of a single month or year.

During the years 1906 and 1907, the Wachusett reservoir was filling for the first time, and the storage capacity was therefore taken as equal to the maximum quantity of water held in storage during each of these years. In the year 1907, there was an abnormally high run-off during the last three months, which was reflected in the high color of the water during the first two months of 1908, and in order to give a truer comparison those three months were included with the year 1908.

Decolorization of Water by Storage.

Name of Reservoir and Supply.	Years Used in Average.	No. of Years Used.	Area of Watershed. Sq. M.	Storage Capacity. Total.	Storage Capacity. Per Sq. M.	* Yield per Sq. Mile. Mil. Gal.	Length of Storage. Days.	Average Depth of Res'r. Ft.	Color of Influent Water.	Color of Water at Dam.	Per Cent. Color Remaining.	Per Cent. Color Reduction.
Stripped Reservoirs.												
1. Wachusett	1908–1914	7½	118	65 000	550	0.894	615	48	43.5	14.7	34	66
2. Wachusett	1907	¾	118	38 600	327	0.920	355	39	45	23	51	49
3. Wachusett	1906	1	118	34 500	292	1.043	280	38	46	24	52	48
4. Hopkinton, Sudbury	1895–1897, 1899–1903	8	5.86	1 520	260	1.111	234	25	113	60	53	47
5. Ashland, Sudbury	1891–1897, 1899–1903	12	6.43	1 416	220	1.066	206	26	100	65	65	35
6. Reservoir No. 3, Sudbury	1891–1896	6	27	1 180	45	1.012	45	15	84	69	82	18
7. Reservoir No. 2, Sudbury	1900–1903, 1905–1914	14	47	530	11.3	0.863	13	12	76	69	91	9
8. Fall Brook, Leominster	1898–1903, 1905–1913	15	1.26	386	306	1.075	285	14	36	15.5	43	57
9. Hobbs' Brook, Cambridge	1900–1903, 1905–1914	14	7.25	2 097	289	0.863	335	14	59	18	30.5	69.5
Unstripped Reservoirs.												
10. Borden Brook, Springfield	1910–1914	5	8	2 500	312	0.925	338	36	75	57	76	24
11. †Milham Brook, Marlborough	1901–1903, 1905–1913	12	3.56	315	88	0.853	103	15	47	45	96	4

* Based on Wachusett or Sudbury records for the years given.

† Stripped to 10 ft. below flow line, but oxygen becomes exhausted in deep portion.

In determining the colors of the inflowing water, the average color of the inlet was weighted in accordance with the quantity of water flowing each month, this being based on the run-off records of the Wachusett or Sudbury watershed, as appeared most comparable. In the single case of Reservoir No. 2, the direct average of the influent colors was used, as the reservoir contained but thirteen days' average run-off. The reservoir colors are direct averages of the published monthly records. All colors were given in or converted to the platinum standard.

Reduction of color is not only a function of the storage per square mile, which is the base used in the accompanying diagram, but also of the run-off per square mile. In this connection it must be noted that the records available for the Wachusett reservoir cover a period of abnormally dry years, and a slightly smaller reduction must be expected when the yield is high. The records for the Sudbury reservoirs, on the other hand, are for years when the yield was above the normal. The number of days that the average yield is held in storage would be the more logical base, but the one used shows the results closely enough and is definite.

To obtain an accurate measure of the bleaching accomplished, the bulk of the inflow must be brought into the reservoir by a single surface stream, or by several streams, the relative discharges of which are known. Such conditions were substantially realized in the cases of the reservoirs studied. In general, the rainfall and evaporation will about balance, so that but little dilution takes place from rainfall.

Results.

The results appear in the accompanying table and diagram. The diagram shows as abscissæ the storage capacity of the reservoir per square mile of watershed, and as ordinates the per cent. reduction in color of the inflowing river water resulting from its passage through the reservoir.

It will be seen that the curves determined by the points plotted show a progressive reduction in color as the storage per square mile increases. This reduction in the case of the Wachusett

amounts to 66 per cent. The line for unstripped reservoirs is added only to indicate the general position on the diagram, as the data are too limited and too variable in this case to justify any analysis.

DIAGRAM SHOWING REDUCTION OF COLOR BY STORAGE

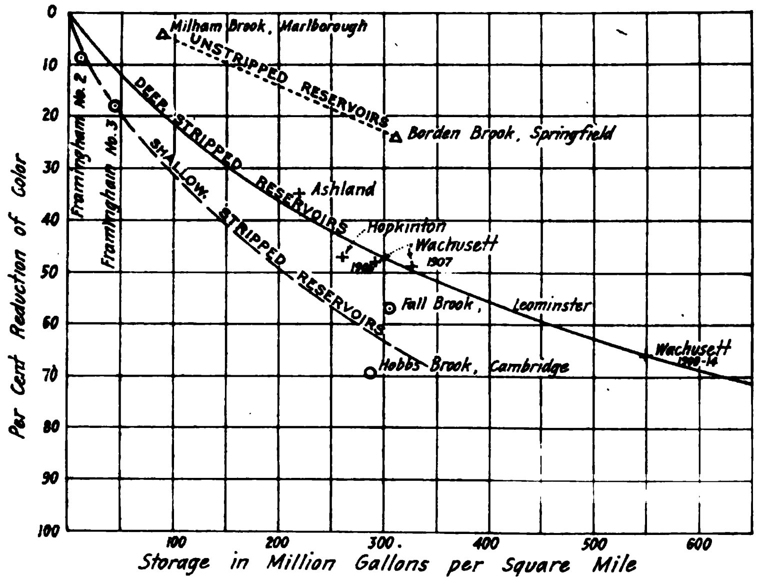


Fig. 1.

The maximum color in a reservoir is normally attained in May or June, following a period of heavy inflow, after which the bleaching takes place actively and the color decreases until another flood period occurs.

The maximum color of the influent of the Wachusett for any month was 70, while the maximum of the reservoir near the dam for any month was 29. This color resulted from the 1907 floods, before the reservoir had filled for the first time. In 1911, as a result of very small inflow, the bleaching action went on until the color was reduced to 7, which color obtained from the surface to the bottom of the reservoir. This color was maintained for a period of three months, while the color of the influent for these same months, which was of considerable quantity, averaged 45.

The color of the influents of the Ashland and Hopkinton reservoirs on a few occasions exceeded 200 during the months of small run-off of the years above noted, while the maximum recorded color of the reservoir water near the dam was 107 for the Ashland and 96 for the Hopkinton reservoir.

The colors for the month of each year in which the color was a maximum were averaged in the case of the Wachusett, Ashland, and Hopkinton reservoirs, and the reduction in color was found to be about five sixths of the average reduction for the year shown in the diagram, when compared with the same influent colors. This indicates the insurance against the highly colored water reaching the distribution system.

Evidence, other than the bottle experiments, which points to the effect of sunlight in accelerating the bleaching, is found in the shallow Fall Brook and Hobbs' Brook reservoirs. These have an average depth of 14 ft., and show a much greater percentage reduction in color than the Ashland and Hopkinton reservoirs of about the same storage per square mile but of higher color and almost twice the depth. The bleaching which takes place in the upper few feet of the reservoir is apparently many times as rapid as that which occurs beyond the range of the sunlight, but, due to intermixing with the waters just below, complete decolorization at the surface of reservoirs is never accomplished. These considerations would indicate the advantage of shallow reservoirs, in this respect.

The results at Borden Brook and Milham Brook reservoirs show the effect of leaving the soil, etc., on all or a large part of the reservoir bed. For a period of years color is absorbed from the reservoir bed, and this in a measure offsets the normal decolorization due to storage. There are instances where for this reason the reservoir color exceeds that of the influent streams.

In order that advantage can be taken of the bleaching effect, it is, of course, necessary that the supply be taken from the lower end of the reservoir and that the greater part of the inflow shall be at the more distant points. In such a case, a somewhat imperfect piston action takes place, and the raw river water travels but slowly toward the outlet. To obtain the best results the reservoir capacity should exceed the maximum run-off of the

winter and spring months, in which case most of the influent would be subjected to a summer's bleaching before using.

Where a large portion of the inflow comes in near the lower end of the reservoir, a more general mixture of the water occurs. Even if it all comes in at the upper end, it is conceivable that an abnormally cold or warm inflow, having a greater or less specific gravity than the reservoir water, might run along the surface of, or beneath, the reservoir water and later become generally mixed with it. In the last two cases the reduction would be the result of dilution and would yield a less desirable effluent. There is evidence of a slow circulation in all reservoirs, due to winds and temperature changes, together with the piston action.

It is now recognized that the reduction of the color to an inappreciable amount is one of the requisites of a satisfactory supply, and, due to its great storage, the Wachusett reservoir seems to have performed this function acceptably.

DISCUSSION.

Mr. Alexander Potter.* Would Mr. Stearns give us a more extended definition of the three terms, — an unstripped reservoir, a deep stripped and a shallow stripped reservoir? I think that has some bearing upon the interpretation of the results.

Mr. Stearns. A stripped reservoir is one in which the soil containing organic matter has been taken off the bottom.

There should properly have been a comma between the two adjectives on the diagram; a deep reservoir and a stripped reservoir was meant.

Mr. Potter. A distinction can very properly be made between "deep stripping" and "shallow stripping." Practice in reservoir stripping has been modified considerably within the last ten years. Then it was considered proper to remove all roots to a depth of 2 ft. to remove all soil containing organic matter, and to take other precautions involving great expense to secure a clean bottom. This method can properly be called "deep stripping." At the present time, it is considered proper to allow roots and stumps cut down to the surface to remain in place over the major portion of

* Civil Engineer, New York, N. Y.

the reservoir, covering such stumps with gravel and clearing off the brush, grass, and vegetable matter by burning. This method can properly be called "shallow stripping." It is not an unstripped reservoir.

The writer was in hopes that Mr. Stearns's studies on "decolorization" would adduce some proof that the more recent practice of less thorough and less expensive reservoir bottom clearing was justified. The paper, however, seemingly confines itself to conditions under the two broad classifications, stripped reservoirs and unstripped reservoirs.

MR. STEARNS. The operation of removing the trees, stumps, and vegetation is, I think, more generally spoken of as "clearing," and the reservoirs referred to in the paper as "unstripped" were "cleared" in such manner. The comparison Mr. Potter desires is therefore shown on the diagram as far as it goes.

MR. EDWARD D. ELDREDGE.* I would like to ask the speaker if he can inform us a little more fully on the spring and fall overturn, — the cause and the process.

MR. STEARNS. In the summer the surface water is very much warmer and very much lighter in specific gravity than the lower water. As the surface water cools in the fall, it becomes heavier, and when it gets cooler than the bottom water it begins to sink down and the whole reservoir mixes up together. It takes an uniform temperature, an uniform color; uniform in all its characteristics. The same thing occurs again in the spring when the surface water warms up from the freezing point to the temperature of maximum density.

MR. ALLEN HAZEN.† There is one practical difficulty in carrying out an investigation like that which Mr. Stearns has described, which has always seemed very formidable to me, and I would like to know just how Mr. Stearns managed it, — that is, to find out just what the color of the incoming water really is. Mr. Stearns gives some statistics for the Borden Brook Reservoir. Now, I am not aware of any record that shows adequately the color of the incoming water. It is true that certain examinations are made, but the flows fluctuate, and the flood flows are very slightly

* Superintendent of Water Works, Onset, Mass.
† Consulting Engineer, New York.

represented in the monthly samplings, and the low water flows are given an undue representation. Then there are many tributaries and only some of them are sampled. Certainly the samples do not represent all of the water, and I, for one, should admit right off that I do not know of any way by which the color of the incoming water can be determined.

In a broader aspect of the case, the result of my study and observation has led to the conclusion that while some improvement takes place in many waters by storing them in open reservoirs, it is never possible to get a water in that way that is acceptable, that is to say, that is up to the standard that cities in this century and this country reasonably demand. The water may be improved, but it is still a dirty, inadequately cleaned water. The only way that these reservoir waters can be made into good water is to filter them; and when the filtering is done the preliminary improvement that comes through these processes which Mr. Stearns has described is ordinarily of very little practical importance.

MR. STEARNS. In answer to Mr. Hazen's question as to how those colors of the influent water were derived, the analyses are made by the State Board of Health in Massachusetts, and each color is multiplied by the amount flowing in during the period which that color represents. If they were monthly it would be weighted according to the flow of water during each month. Thus we obtain the entire mass of color which enters a reservoir during any year, and, by dividing this by the entire amount of incoming water, the average color of the whole influent mass is found. This color is compared with the direct average of the colors in the reservoir near the dam.

In regard to the improvement in the water, the paper showed that the color of the Wachusett reservoir for the past seven years has averaged 14.7, if I recall the figure, which is generally considered a clean water and, as far as the aspect of color is concerned, I think an acceptable water.

MR. W. C. TANNATT, JR.* I noticed on that diagram that the curve of reduction in the unstripped reservoir was practically parallel with the curve of reduction in the stripped reservoir, with

* East Hampton, Mass.

the exception of that point where the capacity was three hundred million to a square mile, watershed. Now, might it not be that if the reservoir was continued, say, to eight or nine hundred million per square mile, the advantage of stripping would disappear because the proportion of advantage is decreasing? Might it not be a fact that there comes a time when the stripping would become uneconomical?

MR. STEARNS. It is a question whether the stripping might be uneconomical or the increase in the size of the reservoir might be. That is, it does not pay to develop the reservoir any further than the Wachusett was developed, evidently, because the line does tend to become parallel with the base line.

PRESIDENT METCALF. Is it assumed, Mr. Stearns, that you take your measurement of the water at the time of the flood flows at frequent intervals? That is, do you take your measurement of color at the beginning of that period only, and assume that that color continues through the period of flow, or do you take colors at frequent intervals during the passage of the flood wave? Wouldn't there be a high color in the first flush of water, which comes from the swamps into the reservoir, and wouldn't the color decrease as the wave recedes? What assumption is made as to the method of determining your color record?

MR. STEARNS. These colors are usually taken monthly, at certain dates, irrespective of any floods, and it is only by getting an average over a large number of years that you can really count on the results. That is what was actually done, for in most cases there were ten years or more in the average, which would neutralize any anomaly in any one observation of one flood.

PRESIDENT METCALF. The analogy to what I suggested would be found, of course, in the first discharge of the sewers in times of storm. There is a great difference in the quality of the effluent that you get from the first flush and the last few hours of the storm. I wondered if that same sort of result was obtained in the flow into the reservoirs. I judge from what you say that it is, but that you hold that it is neutralized by the average. Is that not true?

MR. STEARNS. Yes.

MR. DANIEL D. JACKSON. I was connected with the old Boston

water supply as their chemist, and at that time Mr. Fitzgerald carried on a great many experiments on the decolorization of water by storage, but it was impossible to determine how much color was removed by storage and how much was due to dilution. It would seem from the diagram that the reservoirs having the largest watersheds were the ones which got the greatest decolorization. While we know that there is a decolorization due to the sunlight, that action cannot go very deep beneath the surface. The action must be pretty closely confined to the first few feet of water. It has always seemed to me that the decolorization in large reservoirs was to a large extent due to rainfall and to the flow of water coming in from underground from perhaps other directions as well as from the stream itself, and also to the fact that owing to sudden variations we are unable to gage at all accurately the actual color going in. The final portion of a stream would give you practically a decolorized water. So I should say from the observations taken years ago that the greatest decolorization was due to dilution by rainfall and subsurface flow, though there is undoubtedly a decolorization due to sunlight. Just what percentage that is it is impossible to tell.

Mr. Stearns. Do I understand that that dilution is due to the rainfall that falls directly on the reservoir?

Mr. Jackson. No, on the watershed.

Mr. Stearns. The rain that falls on the watershed is what brings all the color into the reservoir. Otherwise it would be decolorized as the large natural lakes are, like Lake Winnepesaukee and others.

Mr. Jackson. The greatest part of the color which comes into a reservoir is due to the sudden flushing of some swamp area bordering on or at the headwaters of a stream. At the beginning of the flood flow the color is suddenly very high and is then gradually reduced until the dry weather flow is reached, which is fairly low in color. Unless samples and gagings were taken several times a day throughout the entire period of observation, no accurate measure of the color entering the reservoir can be observed. In most reservoirs there is also a constant dry-weather flow, entering the reservoir from below the surface, which is practically colorless, having passed through sand which has removed the color.

In other words, it is a very difficult matter to gage how much decolorization has actually been brought about by storage in the sunlight.

The stripping of small reservoirs for the purpose of removing organic matter is undoubtedly practical, but large reservoirs can be as a rule handled more economically by filling and flushing several times as we did in the case of the New Croton Lake. After the third flushing, the organic matter had been removed and the greater part of the submerged area was found to be clean sand or clay.

MR. R. S. WESTON* (*by letter*). There is a force other than bleaching and oxidation which explains why certain waters decolorize, namely, coagulation.

Much of the coloring matter in water is in colloidal suspension, the particles being so fine that they are not influenced by gravity. They are prevented from coalescing or agglomerating by electrical or mechanical forces, which need not be described. When these forces are overcome by agitation, contact, light, loss of gases, etc., the fine particles gather into groups which are large enough to precipitate. The highly colored Dismal Swamp water (color 500 to 1 000 or more) used to be esteemed highly for the supply of seagoing vessels. After storage in the waterbutts, on board ship, in the dark and constantly agitated, it " works," as the old sea captains say, and becomes remarkably clear and palatable. This " working " process is the sudden precipitation of the colloidal color. The color is not oxidized when precipitated, but may become so later.

The precipitated colloidal matter or ooze must collect on a reservoir bottom, and therefore the character of the water in a stripped reservoir at least must be influenced to a great degree by it, and if the rate of accumulation be greater than the rate of oxidation or consumption by organisms, the ooze, not the bottom, will ultimately determine the character of the water even in an unstripped reservoir. It seems reasonable that the storage of clear waters in dirty reservoirs would impair the quality of a water permanently, and no amount of stripping would prevent the growth of organisms in a water containing abundant food material.

* Consulting Sanitary Engineer, Boston, Mass.

It is to be regretted that there are so few data for unstripped reservoirs. While it is true that the stripped reservoirs of Massachusetts supply waters of the best appearance obtainable by impounding, it is also true that the educated public prefers a water having a color of less than 10 p.p.m. and no disagreeable odor or taste at any time. In most cases this result cannot be obtained profitably by storage alone, and, if other methods of purification are required, it is doubtful if the expense of stripping is warranted.

Mr. Stearns's paper is timely and interesting. It adds to our scanty data on this important problem, all of the factors of which, in the writer's opinion, are not yet known, or if known are not recognized.

MR. E. E. LOCHRIDGE* (*by letter*). The whole question of the decolorization of water by storage is one of a great deal of interest with all water-works men, and especia ly when new storage is contemplated, as a desirable appearing water is being demanded more and more. Iron undoubtedly plays a part as a coloring agent in a reservoir water, but its state is much more complicated than that of a ferrous or a ferric salt. Not only do iron compounds add to the color of the water, but iron salts undoubtedly act as coagulants with consequent color reduction under some conditions. It seems entirely probable that the iron content of a reservoir is in the form of some organic compound and not in a ferrous or ferric salt to any appreciable extent. Only a portion of the iron in many reservoir waters will be removed by oxidation, coagulation, filtration, or by a thorough aëration, or by a combination of these factors. It is entirely probable that a scientific study of the soluble iron compounds of surface water will reveal much, both as to the nature of water, but also the rate and method of decolorization of such waters.

It does not seem to me that the illustrations given by Mr. Stearns, of stripped and unstripped reservoirs, are sufficiently comparable for drawing conclusions as to the decolorization in the two types of reservoirs. Reservoirs for comparison should be of given capacity, about the same length of storage, and they should also be comparable as to depth, location, and quality of water received into them. The elevation above sea level and their usual seasonable temperature ranges, as well as the amount

* Chief Engineer, Springfield Water Department.

which they are depleted during the season, has also a great deal to do with the amount of decolorization. A question of growths in the water and consequent change of organic content must also be a considerable factor. The Borden Brook reservoir, listed as No. 10 in the table, was stripped to a depth of 15 ft., and especial attention paid to the cleaning of the remaining section.

Believing that as good a representative of an unstripped reservoir as could be obtained would be the Ludlow reservoir, which has been notorious for its objectionable growths and tastes for a great many years, I have made a careful study of the flows, depletions, and colors of this reservoir over a number of years. By its peculiar method of use by which the water was by-passed to the city at certain times, I find it is impossible to get records in a number of years. During 1906, however, the city began the filtration of this water, and its use became normal during the last three years of its use by Springfield. The figures for 1906, 1907, and 1908 are given.

Year.	Average Influent Color.	Color at Outlet.	Per Cent. Removal.
1906	49	28	43.0
1907	46	27	41.5
1908	47	27	42.5

The storage capacity of the Ludlow reservoir is 1 855 million gallons, or a per square mile development of 92.5 million gallons, average depth 8 ft. The bottom is thoroughly mucky. As the outlet colors are comparable in other years with the outgoing colors of these years, it is entirely probable that the percentage reductions are substantial to same as in other years. The inlet colors are used in conjunction with the proportional flow for that month. This reservoir was put in service in 1875 and the watershed tributary was doubled fifteen years later. The per cent. color removal in these years of 42.3 would compare favorably with the average of 44.3 in the nine stripped reservoirs listed. Analyses at the filters during these years indicated an iron content in the reservoir which at times exceeded one part per million, while the filter effluent contained at least one half of this amount even after double aëration. Dissolved oxygen was always present, and in the effluent frequently approached saturation.

THE WATER SUPPLY OF SALEM AND BEVERLY.

BY FRANCIS F. LONGLEY, C.E., NEW YORK.

[*Read September 7, 1916.*]

The cities of Salem and Beverly have for many years past taken their water supply from Wenham Lake, which lies in the towns of Beverly and Wenham. This use dates back to the year 1864, when the legislature granted to the city of Salem the right to use the water of Wenham Pond, with a provision that the pipes supplying Salem should be carried by some convenient route through the town of Beverly, and that Beverly should be entitled to the reasonable use of the water upon paying an equitable compensation therefor. The first actual use of the water in Salem was in 1868, and in 1869 Beverly began making use of the water through the setting of certain hydrants.

For a number of years both cities thus drew water from the same mains. The provision for Beverly's compensation to Salem for the water used was not definite enough to be satisfactory to the town people of Beverly, and after some years of effort to adjust this satisfactorily, during which time there were some complaints of insufficient supply and lack of pressure, the selectmen of Beverly were authorized to petition the legislature for authority to take a separate supply from Wenham Lake for the town of Beverly.

As a final result of this action of the town of Beverly, an act of the legislature was passed in 1885 granting the town the necessary authority to build independent works, and construction work was commenced in 1886. In September, 1887, the town of Beverly stopped drawing water from the Salem pipes and commenced the use of this new system.

From that time to the present, the two cities have drawn their supplies independently from Wenham Lake, with independent mains, service reservoirs, and pumping stations.

The draft of water by two cities from one rather limited source

suggests the desirability of joint action in matters pertaining to these supplies. They have, in general, been administered separately since 1887, but as the consumption of the two cities has increased and approached the limiting capacity of the source, the cities have acted in conjunction in securing certain additions to this capacity.

The drainage area of Wenham Lake is about 2 250 acres, including about 250 acres of water surface. The storage in the lake, to a depth of 14 ft., which is about the limit of draft with present equipment, is about 900 million gallons, and this could be increased to about 1 200 million gallons by drawing the lake down 20 ft.

In the early nineties the probability of a shortage of water was so great that the cities were forced into action. In 1895 a dam was built on Miles River forming what is called the Longham Pond. The crest of the dam is at an elevation 5 ft. above the high-water line in Wenham Lake, and a 36-in. cast-iron pipe line conveys the water by gravity from this auxiliary collecting basin into Wenham Lake. After this was done, the total area draining into Wenham Lake was about 4 350 acres, including about 305 acres of water surface. Some years thereafter there was a period of deficient rainfall, during which the water in Wenham Lake dropped to a dangerously low level, and the cities, therefore, made provision to pump water into Wenham Lake at time of heavy flow from a brook flowing from Norwood's Pond, supplementing the supply by the partial flow from about 1.3 sq. miles. It is estimated that the yield in the average year is now about 6.5 million gallons and in a dry year only about 4.7 million gallons a day.

In the year 1914, the average daily draft from Wenham Lake was over six million gallons. It can readily be seen, therefore, that the present situation is a menace to both cities. For some years past they have clearly foreseen the necessity of procuring an increased water supply, and the following steps were taken with this end in view.

In 1910 a report on this subject was rendered to the cities of Salem and Beverly by Mr. William S. Johnson. In 1911 the State Board of Health was directed to investigate the matter of

water supplies for these and other cities and towns, and a report was rendered in 1912. In the same year other reports were made by Mr. Johnson and Mr. George A. Kimball.

In this year of 1912, the prospect of a shortage of water had become so threatening that the appointment of a special commission was authorized by the legislature to consider the entire question in a comprehensive way, the purpose being apparently to fix a basis for the policy of the entire district in regard to water supply for the future. A report was rendered by this commission early in 1913, accompanied by reports from Allen Hazen, consulting engineer, and Guy C. Emerson, engineer to the commission. The substance of their conclusions, so far as they relate to the cities of Salem and Beverly, was that those two cities could most wisely supplement their present supply by pumping at time of flood flow from the Ipswich River into Wenham Lake.

Following the report of this special commission in 1913, the legislature passed an act creating the Salem-Beverly Water Supply Board, consisting of three members, two of whom were to be the heads of the departments of public works of the two cities and the third a non-resident of either of said cities, who was to be appointed by the governor. Under this act the board has proceeded with the carrying out of the work to date. The general purpose of the act was to authorize the securing of an additional water supply for the cities of Salem and Beverly by taking water, under stated restrictions as to time, quantity, and minimum flow in the river, from the Ipswich River at a specified point in the town of Topsfield, to Wenham Lake; to authorize the purification of the entire supply of the two cities when required, and to authorize if and when required the construction of storage reservoirs in order to increase the quantity of water which might be taken from the river under the conditions stated in the act.

The restrictions above mentioned are as follows: The total amount of water taken from the Ipswich River in any one year shall not exceed 2 500 million gallons. Water may be taken only between December 1 and June 1. Water may be taken only when the flow in the river is 20 million gallons a day or greater.

It was left entirely to the board, subject to the approval of the State Board of Health, to determine the details of the project.

The board had for its guidance the reports previously submitted, but the data upon which these reports were based were not complete enough for the board to determine the best and most economical scheme for providing the additional supply.

The board thereupon retained the services of Hazen & Whipple to investigate the various phases of the problem, which included principally the questions of diversion, of storage, and of filtration. A comprehensive topographical survey was at once begun. This survey covered about 9 000 acres, largely in swamp. The work was done in the winter, while the swamp was frozen. The survey yielded information which enabled us to set forth several different plans for storage in the river valley itself, and other prospective storage sites near at hand, and several different methods and routes for bringing water from the river to the lake, the best one of which resulted in a large reduction from the estimates that had been made for the probable cost of the additional supply.

Some years ago the suggestion was actively considered of including the city of Salem in the Metropolitan Water Supply system. If this had been carried through, some arrangement would probably have been arrived at between the cities of Salem and Beverly which would have given Beverly the rights now owned by Salem in the water of Wenham Lake and would have made unnecessary any diversion for either of these cities at present from the Ipswich River. This proposal was, however, rejected by the legislature of 1913 in favor of the plan for diversion from the Ipswich River, after an investigation and report by a special commission.

The entire question of storage of water in connection with the increase of the supply was considered at length. The surveys made covered all the favorable storage areas in and near the lower part of the Ipswich valley. Preliminary plans and estimates were made and reports prepared upon this whole question. From all the conditions, however, it is obvious that the larger storage projects are for the rather distant future; and the smaller ones, while they may be needed before many years, are not imperative at once.

Emphatic attention may also properly be called to the fact that, if some of the restrictive conditions in the act governing the

taking of water could be modified, the addition of further storage to the system could be postponed for many years. None of the restrictions are based upon reasonable data, but seem to have been fixed rather arbitrarily upon the representations of persons whose interests did not lie principally on the side of public opportunity.

Efforts will undoubtedly be made in the future to secure a reasonable modification of some if not all of these restrictions, in order to take advantage of large flows that occur from time to time throughout the year, but that will continue to run unnecessarily to waste so long as the act with its present wording remains in force.

The act of 1913 specified the point of diversion from the river to be in the town of Topsfield not more than 3 000 ft. easterly of the Newburyport turnpike. The records do not show clearly how this limit was fixed. It is supposed that it was fixed thus with the intention of placing the intake above the brook which runs down through the town of Topsfield. If this supposition is correct, some error was made, because the polluted brook just mentioned runs into the Ipswich River several hundred feet above the point of intake authorized in the act. Since the extension of the intake up the river was very expensive, and entirely unnecessary from the point of view of the hydraulics of the system, and since, moreover, there did not seem to be any practical advantage or any greater assurance of a satisfactory supply by carrying the intake above the outlet of Topsfield Brook, the exact point of diversion became a matter of prime importance.

An appeal was, therefore, made to the legislature of 1914 for authority to divert the water at a point much further downstream than stated in the act of 1913, but although this measure was well supported by the representatives of the two cities, Salem and Beverly, before the Legislative Water Supply Committee, the act was not passed, due, presumably, to the opposition of interested parties in the towns of Wenham and Topsfield. Later on, in 1915, after the plans had already been prepared for carrying out the greater part of the project in accordance with the act of 1913, the legislature was again petitioned for authority to locate the intake some distance below the point specified in the act of

1913. This petition was successful and a bill was passed amending that portion of the old act. The plans had been prepared with a view to anticipating this amendment, but could have been very easily modified to provide for carrying the intake upstream in case the amendment had not been secured.

The principal condition specified in the amending act was that the Salem and Beverly Water Supply Board should assume all the expense of changes or improvements that might be deemed necessary within the watershed of the Topsfield Brook, in order to properly protect from pollution the supplementary supply thus drawn for those cities. In compliance with this provision, remedies are now being applied for a number of nuisances and points of pollution in this region.

The plans for the works for the diversion of the water for increasing the water supplies of Salem and Beverly were prepared by us in the fall of 1914. The primary requirement in this design was to provide means of getting large amounts of water in a short time from the Ipswich River into Wenham Lake within the restricted period, and when the river was in flood, in order that the maximum benefit might be secured every year of all the storage capacity of Wenham Lake.

The problem of getting this auxiliary supply from the Ipswich River to Wenham Lake presented some interesting possibilities. All the projects heretofore proposed had been based on pumping from the river through long lines of pipe. Most of these projects had not assumed the rigid restrictions as to time, quantity, and river flow which were required by the act of 1913. These restrictions necessitated a design which would permit the delivery of a large quantity of water in a short time from the river into the lake. Long pipe lines of large capacity cost a great deal, and we naturally tried to find some means of avoiding this. A swamp of large extent lies between the river and the lake. This swamp is so flat as to give the impression of being dead level. It actually slopes several feet in its width, but the general flatness thereof suggested the feasibility of a canal as a cheap means of conveying a large quantity of water some two miles from the river to the edge of the swamp nearest Wenham Lake. This possibility was considered at various angles in comparison with several pipe line

projects, and the plans as generally outlined below were finally adopted.

The plans provide for taking the water from the Ipswich River just below the bridge of the Newburyport branch of the Boston & Maine Railroad, a short distance south of the village of Topsfield. From that point the canal extends in a southeasterly direction across the swamp a distance of about 10 000 ft. This canal is to have a bottom width of 20 ft. at an elevation estimated at 4 ft. below extreme low water in the river. The material through which the canal is dug is swamp muck underlaid by very fine sand. The material as removed from the canal is to be placed about equally on the two banks, leaving a berm of 10 ft. The banks are to be left approximately flat on top, in order that a road may be built later if desired at a minimum of cost. The average depth of cut for this canal is about 9 ft., and the maximum about 13.

The specifications provide that the dredge used for this work is, at the completion of the work, to become the property of the Salem-Beverly Water Supply Board, which will thus enable them to maintain the canal in good condition from year to year.

The accompanying picture shows the dredge at work and shows to some extent the nature of the material. Much of the area was at first covered with trees and underbrush, which were largely cleared off along the line of the canal before dredging commenced. This work was done in the winter of 1914–15, while the surface of the swamp was frozen. The contract for the work was let in the early spring of 1915 to F. T. Ley & Co., of Springfield, Mass., and the work is now well advanced towards completion.

At the southeast end of the canal lies the pumping station. The equipment at present is to consist of one centrifugal pump with a capacity of 25 million gallons per day, to be driven by an electric motor. The floor of the suction well for this pump extends down slightly below the bottom level of the canal. The structure, which is of massive concrete reinforced with steel, is provided with suitable racks, screens, and stop logs. It is designed for a capacity considerably greater than the pump now installed. Provision is also made in the pump-room for the installation of another pumping equipment of capacity at least equal to that now

installed. The power for operating the pump is to be furnished under an agreement with the Beverly Gas and Electric Company.

From the pump the water discharges through a 48-in. Venturi meter into a conduit leading to Wenham Lake. The length of this conduit is 2 866 ft. About 1 415 ft. of this lies practically level on high ground, limiting the height to which water has to be pumped from the canal; 1 406 ft. of the remainder lies on a slope falling rather sharply to the south from this high ground into Wenham Lake, and the carrying capacity required was, of course, obtainable on this steeper slope with a smaller size of pipe. This part of the conduit is, therefore, only 36 in. diameter. The 48-in. conduit and the greater part of the 36-in. are of concrete pipe, which was made on the ground by the Lock Joint Pipe Company. In the 36-in. line, a portion of the conduit crosses a swampy area, and some 411 ft. across this swamp was of cast-iron pipe laid on pile bents. At the point where the pipe discharges into Wenham Lake the bank is to be protected to prevent washing. The lift at the pumping station is estimated to average about 20 ft. for a flow of 25 million gallons per day and for the average stage of the river that is likely to obtain when pumping is permissible.

The system is simple in design and should be quite economical of operation. The large capacity required by the restrictions of the act will enable Wenham Lake to be filled rather quickly when the conditions of flow in the river permit. The whole number of days of operation in a year will, therefore, be small and a good opportunity is presented to arrange for the operation of the works at very low cost. The removal of some of the restrictions placed upon the diversion of water in the act of 1913 would enable the present works to serve without further additions for supply, and at very low cost of operation, for many years to come.

The cost of the work is now estimated about as follows:

Clearing wooded land, 26 acres	$2 800.00
Dredge	7 000.00
Canal excavation, 110 000 cu. yd., at 15c	16 500.00
Supplementary canal excavation, 9 000 cu. yd., at 22c	1 980.00
General excavation, 9 500 cu. yd., at $1.00	9 500.00
General excavation, 2 850 cu. yd., at $1.25	3 562.50
Concrete, 263 cu. yd., at $8.50	2 235.50
Steel reinforcing, 8 090 lb., at 4c	323.60

FIG. 1.
THE DREDGE AT WORK.

FIG. 2.
THE CANAL.

48-in. concrete pipe, 1 415 linear ft., at $5	7 075.00
36-in. concrete pipe, 995 linear ft., at $2.90	2 885.50
Laying cast-iron pipe on piles, 411 linear ft., at $5.80	2 383.80
Pumping station superstructure	1 805.50
Paving, 70 sq. yd., at $1.25	87.50
Construction under roadways	75.00
Appurtenances	1 500.00
Venturi meter and steel pipe	1 478.00
Cast-iron pipe and specials	3 000.00
Centrifugal pump, electric motor, and primer	4 090.00
Private transmission line	250.00
Switchboard and wiring	1 052.00
Other work and materials necessary to complete the work, not covered in above contracts	4 000.00
Total	$73 583.90
Land and right-of-way	14 400.00
Engineering and contingencies, about 15 per cent.	11 016.10
Total estimated cost of work	$99 000.00

DISCUSSION.

Mr. L. M. Hastings.* Mr. President, I would like to ask how much increased storage capacity you will get by this scheme.

Mr. Longley. You get no increase in storage capacity, excepting as the pumping stations of the two cities may increase it themselves by changing the suction arrangements at their pumping stations in order to draw the lake down to a lower level. But the diversion of water from the Ipswich River does not afford any increase in storage excepting that it insures a full lake on the first of June every year, which we have not always had before.

Mr. Hastings. Then, to put the question in another way, how much difference is there between a full level and a low level of Wenham Lake?

Mr. Longley. The lowest that the lake has ever been drawn, if I remember the records correctly, is something like 14 ft. below the full lake, and that 14 ft. gives a storage of about 900 000 000 gal. It has never been as low as 14 ft. at the end of the spring

* City Engineer, Cambridge, Mass.

rainy season. I think the lowest it has ever been at that time has been something like 6 or 7 ft., although I have not the exact figure in mind. There will be a benefit to that extent, and that, of course, is a very marked benefit. That insures, to a large extent, against dry years.

MR. D. W. FRENCH.* I have very much enjoyed Mr. Longley's interesting paper, as it compares favorably with some of the experiences the Hackensack Water Company have had during the last two or three years in preparing several hundred acres of heavily timbered swamp land for a reservoir site and to be excavated by means of hydraulic dredging. About 75 per cent. of the acreage was timber, with some very large trees, and we were confronted with a problem of how best to get rid of the stumps. Before starting the work we visited the dredging work along the New York State Barge Canal, thinking their experience might be helpful, and to some extent it was, although their line of survey had evidently been made, avoiding, just so far as possible, troubles of this character.

After experimenting considerably, we resorted to the use of 45 per cent. dynamite, which we found to be the most satisfactory, and, after blasting, using machines to pull the stumps and their fragments into large piles, and with the use of some oil succeeded in burning them.

After hearing this paper I was interested in knowing how the stump problem had been handled by Mr. Longley, and if his method had been any better or more economical than ours.

After overcoming the stump problem, ours was a case of dredging some 460 acres, the elevation of which was 14 ft. above mean high tide. Between 75 and 80 per cent. of this acreage has been dredged to zero, so that we now have within this area, 14 ft. of water.

MR. LONGLEY. The removal of the stumpage, Mr. French, is a very simple matter. The clearing simply consisted in cutting off the trees a foot or so above the level of the swamp, and that was done in the winter-time, when the swamp was frozen, which is about the only time we can get access to it. Then when the dredge came through it simply dug away at the toe of the bank

*Superintendent Hackensack Water Company, Weehawken, N. J.

FIG. 1.
THE PUMPING STATION.

FIG. 2.
OUTLET ON CONDUIT AT WENHAM LAKE.

ahead of it and the stumps were undermined by that process. Most of the stumps, especially the small ones, came out of themselves. A number of the big stumps have had to be chopped loose from the ramification of small roots, but in no case have they given any serious trouble. We did not have the problem of rooting them up in the same way you had. We dug out from underneath. As far as the disposition of the stumps from the canal is concerned, they were simply thrown over on the banks and covered up by the mud.

MR. JAMES W. BLACKMER.* Mr. President, one point might interest the convention in regard to the cost of the excavation of the canal. Will Mr. Longley tell us the figures that were obtained for doing the work; I refer to the extremely low bid and the extremely high bid, as we thought.

MR. LONGLEY. I cannot quote them from memory, Mr. Blackmer. There was a great variation in the totals of the rather numerous bids, and that variation came largely in the canal figures. The final contract price was 15 cents a cubic yard in addition to the cost of the dredge itself, which was a separate item. The actual cost of excavation, not including any rental of the dredge from the best information we have, does not exceed 12 cents a cubic yard. We haven't very complete information on that, but that is in a general way about what the actual cost has run.

* Superintendent of Water Works, Beverly, Mass.

IMPROVEMENTS TO THE WATER SUPPLY OF THE CITY OF FALL RIVER.

BY H. K. BARROWS, CONSULTING ENGINEER, BOSTON, MASS.

[*Read September 9, 1915.*]

The water supply of the city of Fall River is obtained from the North Watuppa Pond, a large natural pond, about 1 800 acres in area, located just easterly of the city, with high-water mark at elevation 129.5 ft. above high water in Mt. Hope Bay. Water is taken at the west shore of the pond near the foot of Bedford Street and pumped into four large steel tanks, located at different sites in the city, but with overflows all at elevation 305, with a total storage of about five million gallons. Thence the city is supplied through the usual system of pipe mains.

On January 3, 1870, the mayor in his inaugural address called the attention of the City Council to the importance of supplying the city with water, and as a result of his recommendation a committee was appointed to investigate and report upon the matter. This report made to the City Council in August, 1870, included a report by Prof. John H. Appleton, of Brown University, who stated that the water of the North Watuppa Pond was eminently suited for purposes of water supply.

On November 29, 1870, the city purchased the land which is now the pumping station site, on the west shore of the pond, — about 48 acres.

The first Board of Water Commissioners was elected by the City Council on May 8, 1871, and during the next two years the present main pumping station was built, the pumping engine installed, and water mains laid throughout the city. The plant was put into operation January 5, 1874.

During the first few years the income of the Water Department was small, and for many years the city contributed annually to the expense of its operation. No direct appropriation has been made by the city to assist the Water Department since

1897. For the year 1914 the gross receipts were about \$244 000, and the Water Department is the most important department of the city.

The immediate control of the Water Department is in the hands of a board of three water commissioners, a superintendent, a registrar, and various other subordinate officials.

As the North Watuppa Pond and its drainage cover a large area, it became necessary many years ago to give attention to the pond and its adjacent shores, with a view to maintaining the purity of the water supply. To place this matter under definite control, in 1895 the Reservoir Commission was established, which includes the three water commissioners, the mayor, and the city engineer. Since that time a large portion of the land bordering on the shores of the North Pond has been purchased by the city through the Reservoir Commission, and the improvements in the water supply with respect to its quality and adequacy now going on and projected are under the immediate direction of this commission.

Action in regard to the use of the water of the North Watuppa Pond by the city of Fall River began with the Water Act of 1871 passed by the legislature, giving the city the right to take the water of North Watuppa Pond for public and domestic purposes, and under the authority of this act the city elected to take 1 500 000 gal. per day. Under this act the city was required to furnish a reliable means for measuring the amount of water taken, and this has been done since that time, so that accurate records of the amount of water used by the city are available subsequent to 1873.

As a result of this act, in 1880 the Reservoir Company and the mills brought suit against the city for damages sustained by the taking of 1 500 000 gal. per day from the pond, and damages to the extent of \$70 000 were awarded.

In 1886 the legislature granted the city the right to draw 1 500 000 gal. per day in addition to that previously authorized, and under this act the city was not held liable to pay damages sustained by any holder of titles and privileges. A bill was filed in the Supreme Judicial Court by the Watuppa Reservoir Company, claiming this act to be unconstitutional, but in the opinion of Chief Justice Morton in the celebrated "Fall River Water

Case " of 1888 their bill was not sustained. In this opinion it was thought by the court that " the state had the right to use the waters of the great ponds for public purposes and to confer upon cities and towns the right to use the waters without making compensation to the littoral proprietors or to those owning land or water privileges on any stream from the ponds who may be damaged by such use."

In 1891, however, the Watuppa Reservoir Company again appeared in court with regard to the legislative act of 1886 and asked for an injunction to operate against the city. The court reversed the previous opinion, sustained the bill of the Reservoir Company, and issued them an injunction. It was established in this latter action that the plaintiffs were successors in title to grantees of Plymouth Colony, to whom the land under and on both sides of the outlet of the pond and of the Fall River (now Quequechan) was conveyed on March 5, 1680, to Church, Gray, and others for £1100. This grant was known as the " Pocasset Grant " and included all of the South Pond and about half of the North Pond. Consequently the state could not legally delegate to the city the power to draw off the waters of the North Pond to the detriment of the Reservoir Company.

In 1892 an agreement was entered into by the city and the Reservoir Company which has served ever since that time as the basis for use of water by the city. Briefly, it gives the city the opportunity to draw water from the North Pond for purposes of water supply, and only limits the use of water by the Reservoir Company and mills when the water in the South Pond has reached a certain minimum level.

On December 6, 1897, the city took by condemnation the entire North Watuppa Pond, including all the islands in the pond and the land under the pond, for the purpose of preserving and protecting the purity of the water supply, without, however, increasing the amount of water to be taken and used by the city except in conformity with the terms of the agreement in 1892 with the Reservoir Company.

Stringent regulations in regard to the protection of the pond for water supply purposes were made by the State Board of Health in 1907 and have been in force since that time.

The legislative act of 1909 authorized the city to borrow money for the construction of works and protection of its water supply, and it is under this act that the construction of the intercepting drain along the west shore of the pond, to be described later, is now being carried on.

The later legislative acts of 1913 and 1914 are broader in their scope and cover the matter of improving both the North and South ponds and abating nuisances along the Quequechan River. Under these later legislative acts another city commission known as the Watuppa Ponds and Quequechan River Commission is making an exhaustive study covering particularly the improvement of the Quequechan River and South Watuppa Pond, and under the act are to report to the City Council before October 1, 1915.

It will be noted that the city has full power to protect its water supply from pollution, but that the use of the water in the North Pond is shared jointly with the Reservoir Company in accordance with the agreement of 1892, which has been in force since that date. This practically means that the city is entirely at the mercy of the Reservoir Company in respect to the drawing down of water in the North Pond, so that under present conditions storage of water from year to year for purposes of assuring a sufficient water supply is not possible.

The present pumping station has been in use since 1874. It is built of Fall River granite and located on the shore of the North Pond at the foot of Bedford Street Hill. The original pumping engine had a capacity of 3 000 000 gal. per day; during 1914 the equipment is shown in Table 1.

In the earlier days it was intended to have both low and high pressure service; separate standpipes of small diameter were accordingly arranged at the top of Bedford Street Hill for this purpose. In 1886, however, this idea was abandoned and since that time the water level in the tanks or standpipes is at the same elevation in all cases.

At present there are two tanks, each holding about 1 400 000 gal., at the top of Bedford Street Hill, and similar tanks of about the same capacity, one at Townsend Hill in the southerly part of the city and another at Haskell Street in the northerly portion.

TABLE 1.

FALL RIVER MAIN PUMPING STATION. PUMPING EQUIPMENT, 1914.

Pump.	Kind.	Began Operating.	Cylinders. Diameter. Inches. Steam End.	Cylinders. Diameter. Inches. Water End.	Cylinders. Stroke. Inches.	R.P.M.	Rated Capacity. Gals. per Day.	Duty. Million Ft.-Lb.
Worthington No. 1	Horizontal, compound, condensing, duplex, double acting.	1875	29, 50½	22, 22½	48	10	5 000 000	65
Davidson..........	Horizontal compound, condensing, simple, double acting.	1895	26, 48	24	36	20	4 000 000	65
Worthington No. 2	Horizontal, triple, expansion, condensing, duplex, double acting with compensator.	1909	21, 33, 60	24½	36	25½	10 000 000	135

NOTE. — All pumps operate under about 70 lb. pressure. Boiler equipment consists of four Hodge horizontal return tubular, each rated at 150 h.p. under 150 lb. pressure.

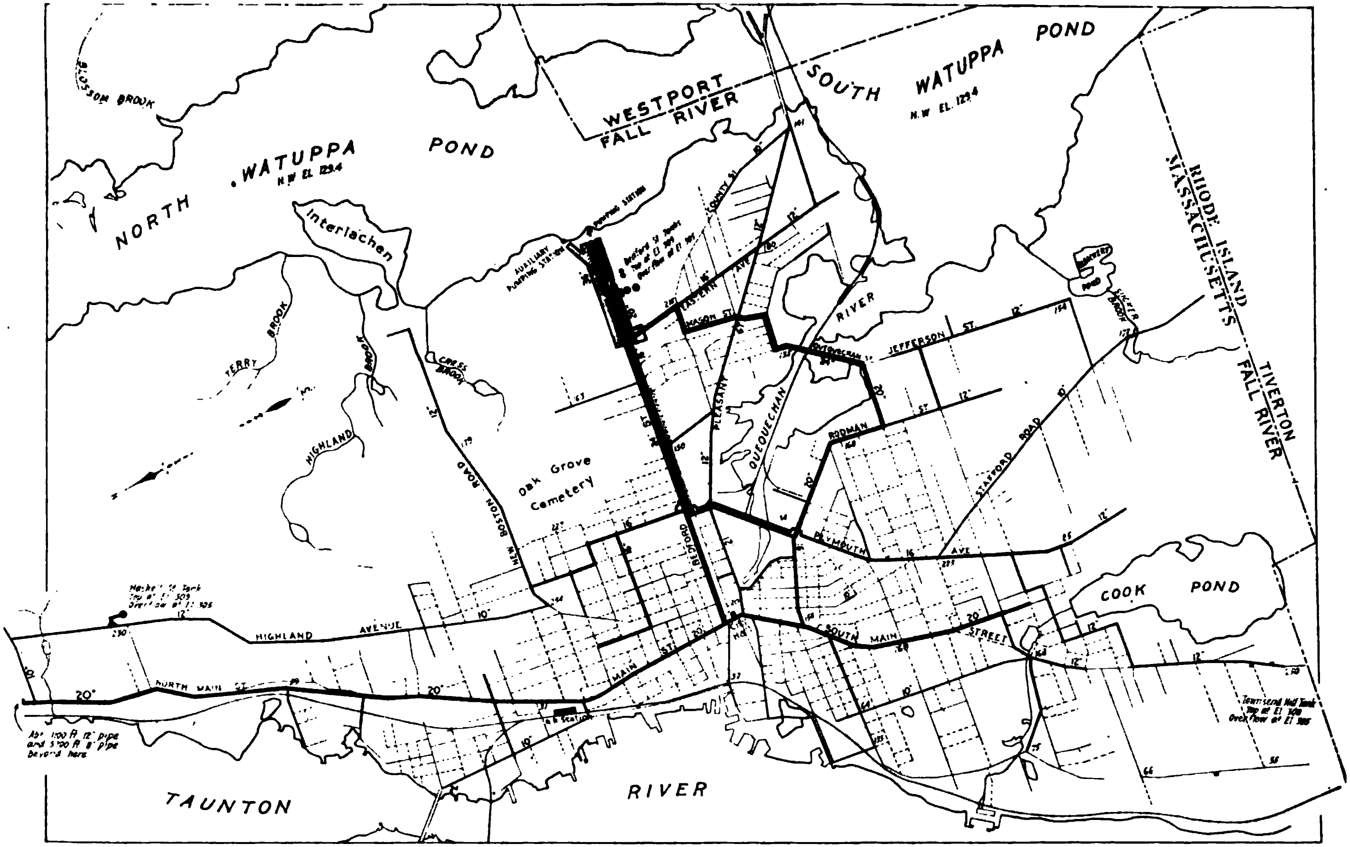


FIG. 1.

CITY OF FALL RIVER WATER SUPPLY SYSTEM, 1914.
Scale about 1 ft. = 10 miles.

NOTE: Figures thus, 230, show elevation above mean high water.

The total capacity of these four tanks is about 5 300 000 gal. As the city uses water at the present time at an average rate of about 5 600 000 gal. per day, it will be seen that the storage capacity of the tanks is very limited, being less than an average day's use. For many years in the reports of the Water Board recommendations were made for the construction of a large storage reservoir on Bedford Street Hill. The great cost of this has prevented its construction, and the city finally adopted the policy of building the cheaper steel tanks and providing a sufficient number of pumping units for a safe supply.

The principal pipe mains of the system, as will be noted on the accompanying plan (Fig. 1), radiate from the 24-in. and 16-in. mains in Bedford Street, varying in size from 24 to 12 in. in the principal streets. These mains are in general laid out with a view to providing ample water for fire protection purposes at the many large cotton mills located in and about the city.

TABLE 2.

CONSUMPTION OF WATER PER CAPITA IN VARIOUS CITIES OF UNITED STATES.

(From Report of Committee on Water Consumption, New England Water Works Association, March 12,* 1913.)

City.	Population.	Water Consumption. Gallons per Capita per Day.	Per Cent. Metered.
Saginaw, Mich.	51 510	186	6.
Peabody, Mass.	15 721	168	..
Boston, Mass.	670 585	130	12.5
Milwaukee, Wis.	373 857	112	98
Cambridge, Mass.	104 837	101	30
Average 35 cities and towns in Massachusetts	......	82	..
Average 17 cities and towns near Boston	......	69	61 (18 to 100 %)
Providence, R. I.	246 000	63	89
Lowell, Mass.	106 294	51	79
FALL RIVER	119 295	44	99
Middleboro, Mass.	8 214	42	..
Marlborough, Mass.	8 202	37	65
Bridgewater, Mass.	11 051	22	..

* JOURNAL N. E. W. W. A., XXVII, 29 (1913).

The advisability of the use of service meters was early recognized in Fall River, and the efforts of the Water Department to reduce waste and misuse of water have been such that at the present time the per capita consumption is low. Practically all services are metered and the present per capita consumption is only about 44 gal. per day. This is seen to be very low as compared with other cities, as will be noted by reference to Table 2.

The Water Department has made special effort to eliminate leakage and waste of water. In 1897 this matter began to receive systematic attention by the department, and a comparison of the amount of water from which revenue was received and of that unaccounted for in 1913 as regards similar data for 1897 (see Fig. 2, taken from 1897 and 1913 annual reports of Fall River Water Department) will show the progress made in this direction. In 1913 about 60% of the entire amount pumped was sold to purchasers, about 12% was unaccounted for, and the remainder used for public purposes, bringing no direct revenue to the Water Department. When it is considered that an amount of water

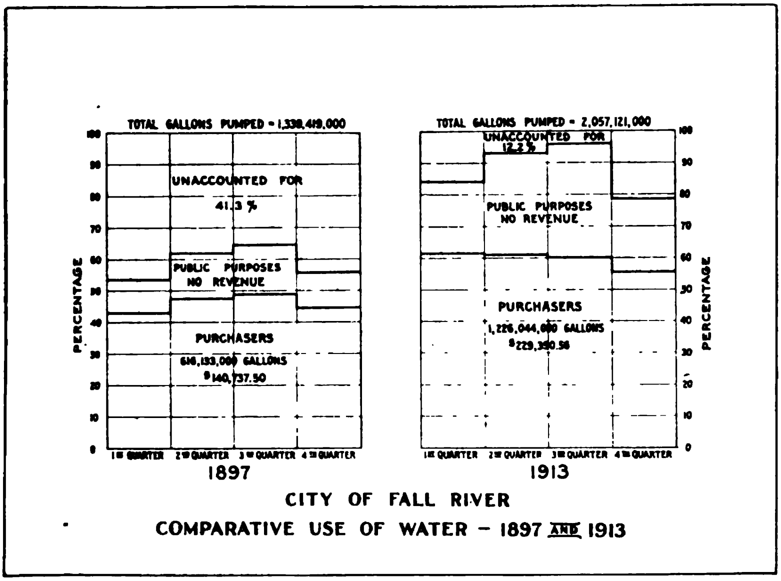


FIG. 2.

unaccounted for of 25% is in general regarded as satisfactory, it will be seen that the efforts of the department have been effective.

During the past year an old Davidson pump at the main pumping station has been replaced by a high-duty pump of 6 000 000 gal. per day capacity when operating under 70 lb. pressure. This has been built by the Platt Iron Works Company, is of the crank and flywheel type, horizontal, cross-compound, condensing, duplex, double-acting. Cylinders are 21 and 44 in. diameter at steam end, and 15¾ in. at water end, stroke 36 in., 36 rev. per min. The guaranteed duty was 140 million ft.-lb. per 1 000 lb. of steam. This pump has only recently been put in operation and has not yet been officially tested.

With the small amount of storage available in the four steel tanks, it was realized that a serious accident at the main pumping station might temporarily cut off the water supply to the city and result in great damage. Among the improvements carried out during the past year has, therefore, been the construction of an auxiliary pumping station located about 700 ft. northerly from the main station on the shore of the pond. This consists of a single story (and basement) station of brick with granite trimmings, about 25 ft. by 30 ft., with reinforced concrete roof and floors. (Plate III, Fig. 1.)

Water is brought to the station through a concrete intake extending about 70 ft. into the pond and terminating in a brick intake house containing a mechanically operated revolving screen.

The equipment installed at the present time consists of an 8 000 000-gal. per day motor-operated single-stage centrifugal pump made by the Wilson-Snyder Company. (Plate III, Fig. 2.) This is operated by a 350 h.p., 1 180 rev. per min., alternating-current, 3-phase, sixty-cycle, 4 000-volt motor, current to operate this being supplied by the Fall River Electric Light Company, so that the motive power of this station is entirely independent of that at the main pumping station.

The guaranteed efficiency of this unit under ordinary running conditions is 75%. This equipment has recently been put in operation, but has not yet been tested.

To still further make this auxiliary equipment independent of that at the main pumping station, a new 36-in. cast-iron main has

FIG. 1.
FALL RIVER AUXILIARY PUMPING STATION AND INTAKE.

FIG. 2.
FALL RIVER AUXILIARY PUMPING STATION.
8 000 000-gallon centrifugal pumping unit.

been laid between the auxiliary station and the tanks at the top of Bedford Street Hill. This will also be available for use by the pumps at the main station. This 36-in. pipe is also being extended as far as Eastern Avenue, where at present a 24-in. pipe leaves the 24-in. main in Bedford Street, which leads directly to the city. The capacity of the entire system has thus been very materially improved.

At the auxiliary station, in the discharge line, is installed a hydraulic gate so that one attendant can have at the switchboard immediate control of the pipe line leading to the hill.

A motor-operated valve is also to be placed, controlling the outlet from the two tanks at the top of Bedford Street Hill by means of remote control apparatus located at the main pumping station. The purpose of this remote control valve is to provide for immediate shutting off of water in case of a break in any of the pipe mains between the pumping stations and the top of Bedford Street Hill.

The approximate cost of the improvements in equipment as noted above (not yet fully completed) is as follows:

Platt high duty pump, including foundations	$20 000
Auxiliary pumping station and equipment (including remote control valve, etc.)	32 000
36-in. force main (about 3 400 linear ft., largely through ledge)	44 000
	$96 000

The Reservoir Commission has made steady progress since 1895 in securing land adjacent to the North Pond and constituting its drainage area, and a large proportion of this is now owned by the city. (Fig. 3.)

On the west shore of the pond is a large tract of land to a considerable extent populated, and in some portions thickly populated, which it has been impracticable to obtain by purchase, and, acting under the approval of the State Board of Health, the Reservoir Commission has, under the act of 1909, taken measures to divert directly to the South Pond, by means of an intercepting conduit running close to the west shore of the North Pond, all the drainage on the west shore beginning with Terry Brook, including Highland and Cress brooks and land adjacent to the pond for the

remainder of the distance to Pleasant Street near the South Pond.

It is of interest to note that in the first published report of the Water Commissioners, dated January, 1875, they recommended the purchase of a strip of land along the west shore of the North Pond from New Boston Road to the Narrows for the purpose of

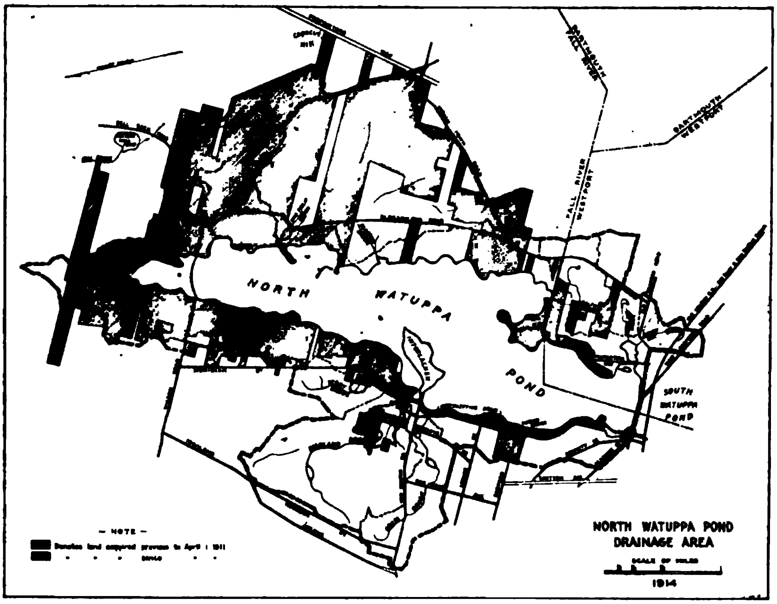


FIG. 3.

building a road and constructing an intercepting drain to prevent drainage from populated districts entering the North Pond. This was the first official suggestion in regard to the construction of this intercepting drain, and the contract for its construction was signed on January 28, 1915, almost exactly forty years from the date when it was first suggested.

The total drainage area tributary to the intercepting drain on the west shore of the North Pond is 2.32 acres. Nearly half of this consists of the drainage area of Highland Brook. (Fig. 3.) Adjacent to the pond, in the general vicinity of County Street, is a little over 0.5 sq. mile of area which in its southerly portion, between County and Pleasant streets, is thickly populated. Of

the total drainage area diverted to the South Pond, probably about one third is in a closely populated condition. The remainder of the drainage consists of grass and cultivated areas. Within the drainage are also two large cemeteries.

Between Terry Brook and Highland Brook, a distance of about 1 962 ft., the drain consists of a 24-in. vitrified pipe laid on a slope of 0.178 per 100, beginning at a small dam and headworks on Terry Brook at Meridian Street. The crest of this dam is at elevation 139.7, and the area flowed at this elevation is about eight acres. The ordinary flow, however, will be taken through a gate at such an elevation that water can be drawn down to about elevation 137.4.

At Highland Brook is a low concrete dam and intake, the crest of the dam being at elevation 139.5. From Highland Brook at Meridian Street to a point near the former channel of Cress Brook, a distance of about 1 500 ft., the drain is of standard 6-ft. open section, with the exception of two short stretches under Meridian Street and at New Boston Road, which are of 6-ft. covered section. This portion of the drain is laid on a slope of 0.0685 per 100. The 24-in. pipe from Terry Brook enters at the side of the 6-ft. open section a short distance below Meridian Street.

At Highland Brook intake the ordinary flow will be taken through a gate, the sill of which is at elevation 132.8. At the elevation of the crest of the spillway there will be a flowage of about 43 acres, and it is planned in the future operation of the drain to close this gate when necessary and hold water for short periods of time in the Highland Brook basin, to prevent overtaxing the capacity of the portion of the drain adjacent to the County Street area, which has steep slopes and will in time be closely built up and, therefore, quick spilling in its nature.

It is intended to divert Cress Brook at a point about 1 000 ft. from the pond directly into Highland Brook, so that advantage can be taken of the pondage at Highland Brook. This diverting drain from Cress Brook is a 30-in. pipe laid on a grade of 0.45 per 100 and was constructed by the Reservoir Commission prior to the time of letting the contract for the main drain, although the actual diversion of the brook cannot take place until the main drain is completed.

TABLE 3.

Section.	Length. Feet.	Size.	Slope per 100.	Capacity. Cu. Ft. per Sec. (Full.)	Total Drainage Area. Acres.	Capacity. Cu. Ft. per Sec. per Acre.	
						Without Pondage at Highland and Terry Brooks.	With Pondage at Highland and Terry Brooks.
Terry Brook to Highland Brook	1 962	24-in. pipe	0.178	10	140	0.07	.....
Highland Brook to Cress Brook (Sta. 105).....	1 576	6-ft. open	0.0685	125	1 120	0.11	.....
Sta. 104 to 79....	2 500	8-ft. open	0.0235	104	(1 150)	0.09	.....
Sta. 78 to 63 ±..	1 500	10-ft. open	0.0235	145	(1 200)	0.12	.....
Sta. 63 to 58....	500	10-ft. covered	(0.0235) (0.104)	(145) (306)	1 240	(0.12) (0.25)	(1.2) (2.5)
Sta. 58 ± to 17 ±.	4 100	10-ft. open	0.104	306	(1 300)	0.24	.....
Sta. 17 to −1 ± ..	1 800	10-ft. covered	(0.104) (0.280)	(282) (462)	(1 385)	(0.20) (0.33)	(1.06) (1.74)

FIG. 1.

FALL RIVER INTERCEPTING DRAIN.
10-ft. open section. Arrangement of forms.

FIG. 2.

FALL RIVER INTERCEPTING DRAIN.
10-ft. open section near Station 72. Completed except grading of banks.

Below the old channel of Cress Brook the drain is of standard 8-ft. open section laid on a slope of 0.0235 per 100 for a distance of about 2 500 ft. For the remainder of the length (some 8 000 ft.) the drain is of 10 ft. section and for the greater part of open section. A short length under Bedford Street, and in the vicinity of the main pumping station is of 10-ft. covered section, as is also a length of about 1 800 ft. in the lower portion of the drain near the South Pond on Pleasant Street. The greater portion of the 10-ft. open section is laid on a grade of 0.104 per 100, although between Pleasant Street and the South Pond the slope is considerably steeper, 0.28 per 100.

In Table 3 are summarized data in regard to size, slope, capacity, etc., of the different sections.

It will be noted that this intercepting drain is of reinforced concrete and consists largely of open section work. This type of drain was decidedly more economical for a given capacity than a covered section. It also materially simplified the matter of the interception of all drainage from the pond and provides a positive cut-off or barrier that will effectively prevent any polluted water from reaching the North Pond.

The details of the various standard sections (with the exception of the 8-ft. open section) are shown on Fig. 4. (See also Plates IV and V.) To localize the effect of expansion due to change in temperature, and consequently of cracks in the concrete, a large amount, about ½ of 1%, of steel reinforcement is used longitudinally, and this is placed in two rows of steel, one near each side of the concrete. The invert is of arched form, although this is obtained by means of chords rather than arcs of circles, in order to simplify the concrete work.

Provision for draining the side walls for a distance of 2 ft. from the top of the wall is made by broken stone filling for a width of 8 in. back of the wall. On the side away from the pond, at intervals of 25 ft., 3-in. tile pipe is set in the walls 24 in. below the top, for drainage purposes. On the side next to the pond no tile pipes are placed, but at occasional intervals drainage channels are provided so that water will not accumulate back of the walls near their top and thus cause danger of frost action and possible pushing in of the wall.

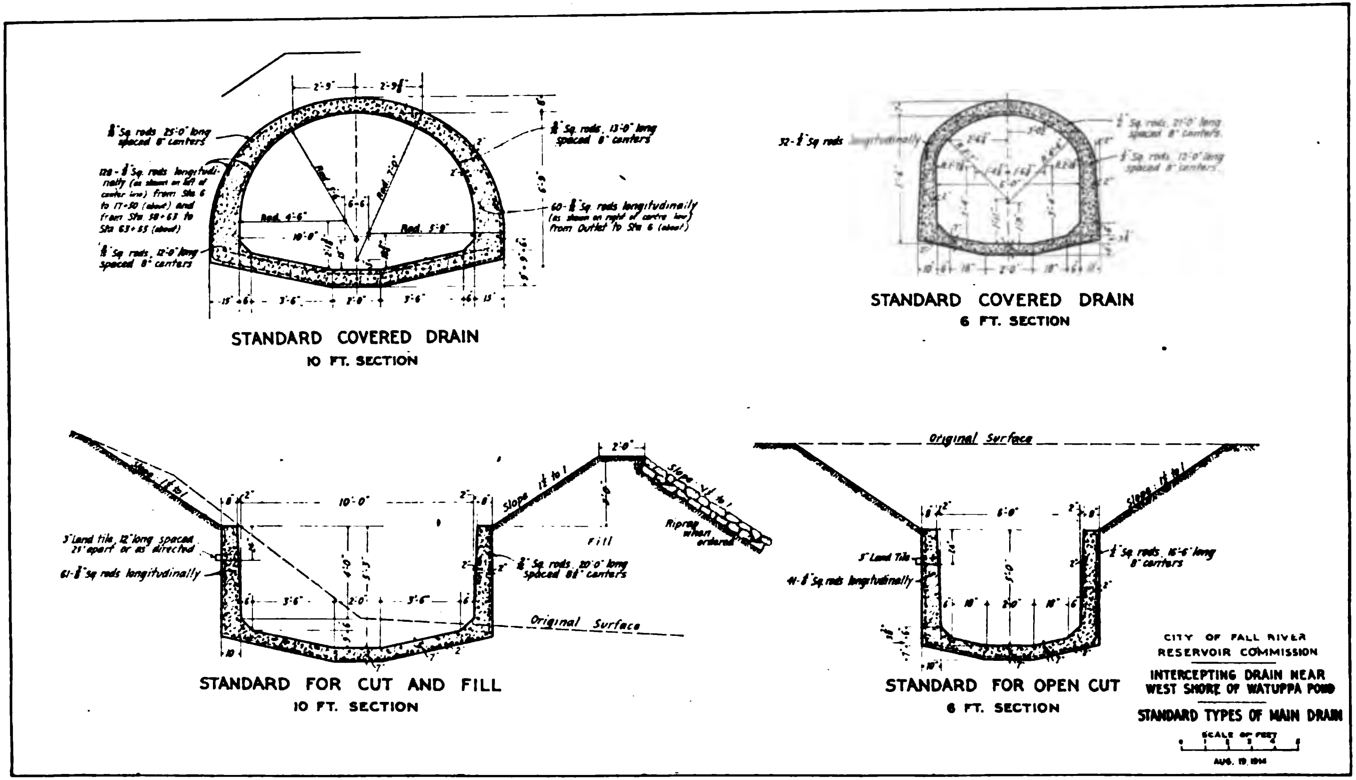

STANDARD COVERED DRAIN
10 FT. SECTION
STANDARD COVERED DRAIN
6 FT. SECTION
STANDARD FOR CUT AND FILL
10 FT. SECTION
STANDARD FOR OPEN CUT
6 FT. SECTION
Original Surface
CITY OF FALL RIVER
RESERVOIR COMMISSION
INTERCEPTING DRAIN NEAR
WEST SHORE OF WATUPPA POND
STANDARD TYPES OF MAIN DRAIN

Fig. 4.

FIG. 1.

FALL RIVER INTERCEPTING DRAIN.
10-ft. open section near Station 44. (200 ft. radius curve.)

FIG. 2.

FALL RIVER INTERCEPTING DRAIN.
10-ft. covered section near South Watuppa Pond. In process of construction.

Great care is being taken in construction to obtain a dense and impervious concrete. The specifications provide for mixing in proportions " to be exactly determined from time to time by the engineer, in accordance with the relative coarseness of the aggregate," — the average relative proportions being from 1 : 2 : 3½ to 1 : 2½ : 4. Frequent sieve tests of sand and broken stone are made to help govern the selection of the best proportions. Thus far the prevailing mixture for best results has been closely 1 : 2 : 4.

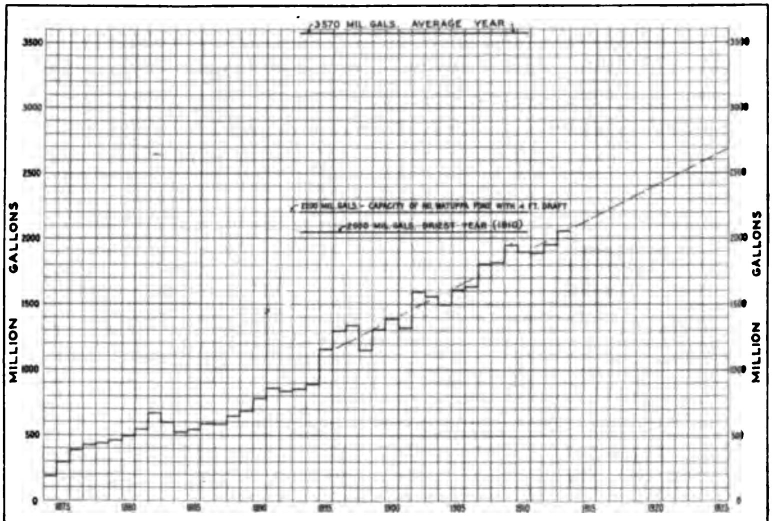
Bids were received on September 4, 1914, ranging in total amount from about $174 000 to about $240 000. Owing to the condition of the bond market last September [1914] it was not possible to sell bonds at par, and as this was required under the legislative act, there was a delay in awarding the contract until January 28, 1915, when it was awarded to the lowest bidder, the Hanscom Construction Company of Boston. They began work as soon as practicable in the spring and at present are making good progress, with more than 50% of the construction completed.

On the easterly side of the North Pond is a very considerable area, portions of which are quite closely populated, which must be diverted directly to the South Pond by an intercepting drain. This includes the drainage areas of the North and South Nat brooks and of Ralph Brook. Recent analyses made of samples of water at different places on these brooks indicate serious pollution and confirm the urgent necessity of this construction.

The general method of diversion has already been approved by the State Department of Health, the detailed plans for this work are now in process of preparation, and the work will undoubtedly be commenced as soon as practicable.

The total drainage area of the North Pond at present, including the area of the pond itself, is about 11.5 sq. miles. The intercepting drain on the west shore of the pond will divert directly to the South Pond about 2.3 sq. miles of drainage. The Nat and Ralph Brook diversion on the east side of the pond will take about 0.7 sq. mile more. The total area to be diverted is thus about 3 sq. miles, leaving for water supply purposes about 8.5 sq. miles of drainage area, of which 2.8 sq. miles is water area. The capacity of this 8.5 sq. miles of drainage area of water supply may be roughly estimated in the following manner:

For the average year the precipitation is about 47 in., and from measurements of the yield of the pond made covering two years, it has been found that about 50% of the precipitation is available as yield, the remainder being used up by evaporation, the demands of vegetation, and other losses. On this basis the total amount



CITY OF FALL RIVER
WATER CONSUMPTION 1874 - 1913

FIG. 5.

of water available for the average year would be about 3 460 million gallons. In a dry year like 1910, when the precipitation was about 34 in., probably not over 40% of the precipitation can be utilized, or a total of about 2 000 million gallons. The total amount of water used by the city during 1913 was about 2 050 million gallons, and this amount is increasing from year to year, as will be noted by reference to the accompanying diagram. (Fig. 5.)

This approximate analysis shows that even at the present time storage of water in the North Pond would have to extend over more than one season in order to assure an adequate supply in a very dry year, after the diversion of drainage contemplated by the improvements now being carried on.

Under the present agreement, the Watuppa Reservoir Company can draw water from the North Pond without any limitation until the pond is at about 40 in. below "full pond." It is evident, therefore, that under present conditions the North Pond cannot be used by the city in storing water from year to year for water-supply purposes, and there is likely to be a shortage of water at any time after the diversion works are completed.

The additional problems before the Reservoir Commission are, therefore, first, to obtain for the city complete control of the waters of the North Pond, and, second, to supplement the water supply from some other source. To assure an adequate water supply these measures must closely follow the diversion improvements now under way.

DISCUSSION.

MR. FRANK L. FULLER.* I would like to ask what the city pays for the current which they use for the centrifugal pump.

MR. BARROWS. The cost of power for pumping is in accordance with a sliding scale; the first 50 000 kilowatt-hours at $1\frac{1}{2}$ c. per k.w.h., the next 100 000 at 1 c., the next 150 000 at 0.9 c. The new pumping station will be for some time to come used simply as an auxiliary station, at such times as the main station is shut down for repair or in case of emergency, consequently the rate paid will be nearer the upper portion of the scale.

MR. PERCY R. SANDERS.† I would like to ask how you get the figures for the water accounted for, shown on Fig. 2. Is the water used by the street sprinkling carts and the different city departments measured by meter?

MR. BARROWS. Certain of the public uses of water have to be estimated, as meters are not used in all such cases. These estimates are, however, controlled from time to time by tests or by the temporary installation of meters in order to insure that the estimates are reasonable.

* Civil Engineer, Boston, Mass.
† Superintendent of Water Works, Concord, N. H.

DETAIL METHODS USED IN THE FORESTATION OF WATERSHEDS.

BY SIDNEY K. CLAPP, ASSISTANT ENGINEER OF THE BOARD OF WATER SUPPLY, NEW YORK.

[*Read September 8, 1915.*]

The ordinary methods followed by foresters and nurserymen in the propagation of small trees from seeds are too well known to need any description. There are, however, various experiences which may be of interest if explained in detail.

The gathering of seed is one of the first points to be considered. A careful inspection of the cones or seeds on the trees will determine whether they are in a proper condition to be gathered; a change from dark green to brown is a good indication. A few hours is often sufficient to fully ripen the seeds, and a sudden gust of wind will spread them in every direction. A very unique and satisfactory method of gathering conifer seeds, has been used extensively at the Ashokan Reservoir of the Board of Water Supply, City of New York, where several hundred thousand trees are grown annually. At just the time when the seeds are ripe and the cones opening, blankets, sheets, and cloths are spread on the ground around the tree and the tree violently shaken; there should be no perceptible wind at the time. The seeds fall on to the cloths in a shower resembling a heavy snowstorm, and a considerable quantity of perfectly clean seed results with little effort. At other times it is necessary to pick the cones just before they open, storing them in burlap bags until they can be spread on proper racks to ripen and dry, when they are threshed and cleaned or winnowed.

After the preparation of the seed beds with their racks and the planting of the seed, which is described in several books and circulars on this subject published by the state and government departments, the real trouble begins.

The seed, being oily and nutritious, is much sought after by

mice and birds, which will destroy thousands in a very short time; even when they are well out of the ground, the birds will pick off the little seed cap, killing the tree.

After this experience with birds and mice comes the scourge called mildew, and thousands of small trees " damp off," when it is impossible to secure the proper sunlight to dry the ground sufficiently. Too much sunlight at such times will cause the small plants to " wilt " and die, so that a happy medium must be secured. It has been found that dry road dust will often prevent or stop mildew when no other remedy is available.

Considerable trouble is caused by a thin covering of green moss which grows on the surface of the ground and is at times almost imperceptible, but apparently saps the vitality of the plants, restraining the proper moisture and air from entering the soil. Some seedling trees, such as the hemlock, apparently are not affected to any extent, as this seems to be their natural environment. Dry road dust has been very effective in the treatment of this problem.

After the small trees have passed through the various overground scourges, they are often attacked from beneath the surface. You will be surprised at visiting your seed beds some morning to discover that quantities of small trees have grown suddenly shorter; their little leaves lie flat on the ground as if the roots had become deeply imbedded. If they are raised from the ground you will find that there is no stalk and the entire root has disappeared. If you sacrifice some of the trees in the immediate vicinity and dig up the ground to a depth of several inches you will invariably find either a small white grub half an inch long and about the thickness of the lead of a lead pencil, or a full-sized white grub as large as your finger and an inch or two in length. No spray or solution has yet been found which can reach these grubs without affecting the small trees. A method which was used to some extent in exterminating the large grubs was to make a comb out of hatpins spaced about one-half inch apart; thrusting these into the ground over the affected area, piercing the grub and killing it.

Even when the small trees are covered with burlap or evergreen boughs to prevent winter-kill, it is necessary to watch them, as

field mice will enter under the coverings and cut away the small trees, which they use for nests, leaving only the stubs. Sowing wheat and other grains soaked in strychnine throughout the beds before covering them is quite effective, but even with all this care the mice will sometimes attack the trees and in a few days do great damage.

Winter-kill is another source of danger, and this may occasionally be traced to the fact that the seed used came from a milder climate producing trees which are not hardy when grown in this region; hence it is important to be sure of the character and quality of the seed. In one instance several pounds of Douglass fir seed was ordered, and it was specifically stated that this should be "Colorado Douglass fir seed." A stenographer or the purchasing agent, in an endeavor to abbreviate, changed the word "Colorado" to "Cal.," which was immediately accepted by the seed agent to mean "California," and as such the order was filled. These California seeds were not hardy, and the result was that several thousand trees were winter-killed.

Spring is the busy time in the nursery. The two-year-old seedlings are carefully lifted, gathered in bunches, and their roots immersed in a thick solution of muck, of the consistency of soft tar. These are then carried to the men at the transplant beds. At every operation where a small tree is successfully moved it is necessary that the covering of the root be kept moist, and bog muck has at all times been a most efficient material.

Various methods have been tried out in planting trees in the transplant beds. Transplant boards, racks, and other devices were used but finally discarded. The method employed is as follows: A line is stretched lengthwise of the bed, which for convenience is made about 6 ft. by 50 ft. A square-pointed short-handled shovel, flattened on an anvil, is guided by this line and pushed deep into the ground and swayed from side to side, leaving a well-defined slot or groove. The planter follows immediately on one knee, and with a single operation drops the root into the soil, firming the ground about the small tree, and advances three or four inches, as the case may be, repeating the operation. The rows are about eight inches apart. With a little skill a man can plant about a thousand trees in an hour and have every assurance

that the roots are deeply imbedded and will not succumb to the subsequent dry-weather periods. This will also prevent in a great measure the heaving by the frost, which is so fatal to transplant beds in this region.

From a considerable experience with various kinds of seed, it is found that certain varieties are more hardy and better adapted to the soil and climate at hand. For this reason it is well to try a great many varieties before accepting any one or two as a basis for a large planting. The greatest part of the seed on the market is of foreign origin, is not true to name, and, when purchased by competitive bidding, may be poor and not worth the necessary trouble to grow. Our experience has been that it is far better to collect native seed from local sources than to run the risk of purchasing seed that is poor in quality, diseased, or unsuited to the climate. In one or two cases seed was purchased which took two years to germinate. This is true of some of the junipers, and it was remarkable to find not a seed coming up the first year, but a fairly good stand the second year. In another case seed was planted in the fall in the natural way, but the germination and subsequent growth was quite irregular and not as satisfactory as when planted in the spring.

It is often necessary to spray certain areas which become affected with the woolly aphis, a soft green worm or slug covered with a white exudation appearing like cotton. There is also a pine worm which is so nearly the color of the small trees that it is hardly noticeable until it has done considerable damage. These come in large numbers and work rapidly; they have been destroyed with tobacco or oil emulsions. The weevil, which destroys the leaders of larger pine trees, can best be checked by cutting and burning the affected branches several times during the season. To combat the white grub, the soil, which should be a light, sandy loam, has been treated with air-slaked lime and old plaster from buildings, also with salt; it has been cultivated several times during the year and various cover-crops tried; it has also been thoroughly plowed at intervals and just before heavy frosts, but with all these precautions there remain infested areas which it seems impossible to eradicate. It is also surprising to find that the grubs have a selection or choice, and that they will attack certain varieties of

trees, passing by or under other varieties for which they do not apparently have a taste. A very interesting experiment was tried by planting some of these trees, such as the Colorado blue spruce, for which the grubs have a particular liking, among trees of the native red pine. This, so far, has worked out very successfully, but it may not be entirely successful as the grubs will probably find the spruce before long and will then go through the entire row, doing great damage before it is discovered.

No success has ever been attained in fall transplanting from transplant beds to the open fields, and this should only be resorted to in case of necessity. In one case 99 per cent. of 20 acres of planting was winter-killed.

The greater part of the forestry work at the Ashokan Reservoir, outside of forest improvement, has been devoted to the raising and planting of conifer trees, because they are not as common as deciduous trees, present a pleasing appearance to the landscape, and act as a screen to the ground at all times of the year, although a considerable number of oaks and white ash have been successfully raised. Many of the old wood-lots which were littered with undergrowth, dead tops, and branches have been improved and thinned out, the better types among the trees being preserved for future forest stands.

(The discussion of this paper will be found on page 74.)

COSTS AND RESULTS OBTAINED IN REFORESTATION OF THE CROTON WATERSHED.

BY T. C. CULYER, ASSISTANT ENGINEER, DEPARTMENT OF WATER SUPPLY, GAS, AND ELECTRICITY, NEW YORK.

[*Read September 8, 1915.*]

Forest-tree planting on the city's watershed is a comparatively recent enterprise. The first attempt in the nature of elemental forestation by the Department of Water Supply, Gas, and Electricity was made in the spring of 1912, and was applied to portions of the extensive area of land owned by the city, which comprises a material part of the catchment areas in Westchester, Putnam, and Dutchess counties, in this state.

Its significance, if any, lies in the fact that it was a beginning where usually, as in most enterprises, it is the first step that counts. There have been, however, other and earlier undertakings of this nature hereabouts and in neighboring states, where the experience and results have proved satisfactory and have seemed to encourage and justify a continuance and decided enlargement of the work. That of the Board of Water Supply of this city carried on over territory under their jurisdiction at Kensico and Ashokan is notable for its extent and promising results. That department, fortunately, is in command of larger financial resources than the Department of Water Supply, and has a freer hand in using them for this laudable purpose. The work is being thoroughly done, to its future advantage and for the public benefit.

Owing to the fact that our planting operations cover a period of less than three years, sufficient time has hardly elapsed in which to have obtained, by observation and study, any substantial data, other than that, in a limited way, to be herein submitted.

You are probably familiar with what has been accomplished in and about the city of Boston, several years ago, by the Metropolitan Commission, over the denuded Blue Hill Reservation in particular. Here the purpose has been to renew and restore

indigenous vegetation to this reservation, covering a very large area, and upon which substantial trees and shrubs have been placed. The development and growth of this material has made satisfactory progress in large part over the whole area, and the visible results are already suggestive, to one familiar with its former run-down and unkempt condition, of lively promise of a renewal of the woodland effect and the wild verdure which in earlier days existed over this rugged and picturesque country.

The titular watershed constituting the source of water supply for the city of New York encloses a territory, partially extending into the state of Connecticut, of 362 square miles area. Within this, and confined to the counties of Westchester, Putnam, and Dutchess, the city has acquired and now owns some twenty-two thousand acres, wherein is contained numerous storage reservoirs, lakes and ponds, together with existing streams and other natural sources of water. For the purpose of this article, the land comprising the Catskill domain is not considered. The large quantity of land in excess of that occupied or required for storage purposes, dams, and other structural features, affords ample means for safeguarding the streams against pollution and other undesirable contingencies, which was the primary object of its acquisition. The course of this property is long drawn out, comprising divergent localities which form sites and protected areas for reservoirs and numerous streams, the natural eccentricities of which influenced the problem of its original taking. You will surmise, therefore, that we have, as in the Catskill and Blue Hill reservations, considerable units of land upon which to outline and carry on any formal forest renewal as a permanent feature of the landscape, or for ultimate commercial purposes. With this general limitation in view, we have planted in certain localities many trees on ground within and nearby the several villages within the watershed and about the dam sites where conditions permit, and in long stretches adjacent to the public roads. These trees, some of them three years old, are very promising in their growth, reaching a height of five feet or more in attractive characteristic form, and unquestionably have invited public attention and approval.

We have used three and four year old transplants consisting of white and Scotch pines and spruce, secured from the State

Conservation Commission. The cost of the plants for the first two years averaged $4.25 per thousand, but this spring they were supplied for fifty cents per thousand, the city, however, in both cases paying the express charges.

Close planting is generally recommended for reforesting work, the object being to secure straight stems and reduction in knot wood growth. The plants are certain to grow in open ground, on the removal of other surface vegetation. In preparing for planting, we removed the grass and other growth for a space of about two square feet, at the same time the hole was excavated for planting. Incidentally, this served as an additional safeguard against fire.

The work of planting proceeds as follows. The tree sites having been prepared, two men, constituting a planting gang, go upon the ground, one ready to plant, the other carrying a number of plants in a pail in which a sufficient amount of water is supplied to keep the roots of the plants moistened, and from which pail the plant is passed to the man who is to plant the tree. The cost of this proceeding has been one cent per tree, and it has so far proven reasonably satisfactory, since our loss during the three years' experience has been within fifteen per cent.

It will happen that, within some area with which you may have to work upon, there will not be available any land of considerable extent where you can consistently install the more formal system of forestation prescribed by the authorities. At the same time it may be feasible to plant the same class of trees irregularly in interrupted sequence in quite ample numbers, reinvesting the denuded border of streams and the environment of natural and artificial bodies of water which, without primarily designing to secure that object, will result in imposing upon an extended landscape an effective and attractive feature to the eye.

Our interest, as a people, in forestation has not been general, and, in comparison with its practice in other countries, has been only of recent and fitful concern, while in many states the subject as a serious economical problem is still dormant. Our belated reservations of vast tracts of land, still notable for its natural investiture, have prevented the destruction of an invaluable natural heritage, and these will be added to from time to time,

as the public becomes more intelligent regarding their value to the nation, and approve of the necessary outlay for their acquisition.

Concerning the cost of such work as ordinarily exploited, the figures indicate the attainment of considerable labor efficiency, and handling and planting of from one thousand to twelve hundred plants according to size by a team of two men has been stated as a usual day's work.

The plants at first cost being cheap, it is apparently assumed that comparatively superficial work in planting will nevertheless insure the growth of a substantial percentage, and therefore it is not worth while to deal interestedly with the individual plant. As to the possibility of properly placing one thousand to twelve hundred plants per day, by two men, I "have my doubts." In some of these localities, where this kind of enterprise is contemplated, there is a decided handicap facing the plant at the outset in the meager supply of soil for root covering and support. I believe it would pay, at a slight increase of cost per thousand, to supply a small additional quantity of good soil to each plant. It may be impossible to follow out this plan at present, but it is to be borne in mind that any plant whose body structure shows strength and characteristic development and whose roots are full and fibrous, even at the early stage at which the stock is supplied, if properly planted and thereafter given a fair chance, will replace in value a half dozen weakly or otherwise fairly grown ones which have suffered some impairing injury. This kind of vegetation shares many elements in nature, in common with human beings. They need and thrive on good food and suffer for the want of it, as they do for water or its lack.

However small the plant may be, in placing it permanently in the ground the excavation should be ample enough to allow a full spread of the roots. A small supply of good soil conveniently handy to the planter will enable him to make his work good at little loss of time, and these, as do all plants, will in their own mysterious way gratefully acknowledge a generous "meal ticket" in a more vigorous and promising development. Spring is regarded as the most favorable season for planting, though where a large number of plants are to be disposed of, the work may be successfully renewed in the fall months, until frost. Spring

planting has the advantage of preceding the growing season, during which the plant becomes established in the ground. The effect of drought in the beginning is the most discouraging experience of the young plant, at which time an artificial supply of water if possible is the one thing needful.

Evergreens seem to adapt themselves to most discouraging conditions, yet all like good soil, the better food supply.

The white pine, often growing vigorously in light sandy soil, will respond to good soil in the growth and substance of its timber. It is not adapted to wet ground.

On poor soil the Scotch pine, while less attractive in form and habit and not so valuable commercially, grows hardily, being aided in its efforts to thrive under somewhat adverse conditions by its longer penetrating root. In its native country, it is regarded as we regard the white pine.

Of the spruce, the Norway spruce is to be preferred to the native, and will do best in fairly good soil. It grows, too, better than most cone-bearing trees, in moist ground, and may be used to advantage for under-planting in existing woods. It is, in fact, noted for its hardiness and its adaptability to almost any soil.

The list of trees at present supplied by the state seems to be somewhat restricted. This may have been and is still due to the great demand for plants. It is certain, however, that if variety sometimes quite desirable is sought, there are, in addition to the above named, not a few trees that may be used, especially where the less formal and the more desultory manner of planting is possible. The hemlock is a beautiful tree, and should not be ignored, despite the fact that it is less valuable than most wood, but still profitably available for rough work.

The larch, too, notable for its fine standing timber, hardy and with a peculiar and interesting foliage, grows well in any fairly good soil. Other species of evergreen, including the juniper, of a rather dwarfish tendency of growth in conjunction with stocky low-growing under-wood, are excellent for the formation of thicket and for the borders of stream and pool, offering a fine harbor for birds.

In the matter of tree planting for shade, and the ornamentation of our public roads where conditions are suitable, as indeed they

generally are, if the engineer will give attention at the outset to so desirable an item in the project of road building as tree planting, there should be provided as an integral part of the specifications that trees shall be placed in properly spaced locations and seasonably planted. Under these conditions, the engineer will experience pleasure in having writ "*finis*" upon an enterprise which will retain a very effective feature and show an increasing value of the trees, secured, as he will be surprised to learn, at almost negligible increase of cost per foot of the whole undertaking.

If I may offer a suggestion, a sort of generalization, it is to say that the tree symbolically should constitute a subject of an awakened interest to the engineer, with whose endeavors and enterprises it is in so many ways associated. The engineer is, by virtue of his profession, assumed to be fairly equipped educationally, with normal capacity to comprehend and appreciate abstract and concrete art and science as ordinarily applied in human affairs. He has often been and is likely to be the pioneer and the companion of the pioneer in the successful venture and glory of original exploitations, especially in relation to enterprises where he is to discover at first hand the wonderful features of nature, the surpassing beauty of forest and field, and a surprising contrast of vegetation in all its varied forms. But he has not permitted himself to add practice to this natural and acquired equipment. He has been tethered to the principle generally accepted by the profession, that always his aim must be to build well, under eternally rigid exactions of economy, and prepare the way for others, as the architect, the gardener, and often the superficially equipped empiric, to deal with his creation with a free hand in expenditure denied to him, in applying those features of superficial external adornment, essential to its completion.

DISCUSSION.

MR. CALEB M. SAVILLE.* The watershed of the city of Hartford, located on the easterly slopes of Talcott Mountain, is about twelve square miles in area, of which between five and six are owned and controlled by the Hartford Water Board. Of that

* Chief Engineer, Board of Water Commissioners, Hartford, Conn.

five or six square miles, about 1 700 acres are in a naturally wooded condition, 885 acres in old pasture covered with sprouts and young growth, 85 acres upland used for growing hay, 485 acres water surface, and 230 acres plantation, mostly white pine. The area of old pasture is gradually being planted to pine, about 25 acres being put down in a year. We have had considerable trouble with the pine-tree weevil, which attacks the tops of the white-pine trees. We hope he is like the seventeen-year locust and is getting tired of work, and we will not hear of him again for a long time. We consulted several foresters in this matter, and are now planting red pine, which the weevil is said not to attack and which I am told is about as good for timber purposes. I noticed Mr. Clapp spoke of planting ash. We planted a great deal of ash in the first part of our plantation work, but the rabbits and deer destroyed so much that we have ceased to plant these trees. We plant nothing now but coniferous trees. The chestnut blight has so seriously affected the entire area of our watershed, and that part of Connecticut also, that probably the only remedy is the complete removal of the chestnut tree, and reforestation.

While it is possible theoretically to produce profits from thinning and clearing on forested areas, and most of the foresters whom we have talked with have assured us that we could expect such a profit, it is worth while to note that in our experience such profit is decidedly non-existent, because we have used pipe-laying gangs in the winter time who, while experts with pick and shovel, are not economical woodmen.

Mr. Edward E. Minor.* In New Haven we have been interested in forestry work for quite a number of years. We have a large territory which we own, do our own planting, and raise our own stock. We make a profit on our forestry work. Most of the lumbering work is done under contract on a percentage basis. We use our own men in the winter at times, but we find it unprofitable because they are not accustomed to lumbering work. It requires men who are used to that work to make a profit out of it, as the margin of profit is very small.

We are very apprehensive about fires. We spend a great deal of time in developing fire lines. I have not heard that spoken of

*Superintendent, New Haven Water Company, New Haven, Conn.

as yet. We divide our tract up into various districts and have these separated by lines which are cleared every year, and in the spring and fall we have a gang of men watching. They have a system of signals so that they can bring help if a fire starts. We seldom go through a spring or fall without having two or three very severe fires, which we are able by means of our preparation to control before they do material damage. We have about 1 200 acres planted at present, and are planting about 200 acres a year. The planting costs us about $7 an acre. The raising of tree stock costs us very little. A week's work every spring followed by occasional weeding covers all the work we do on our nurseries. We have to spend considerable time in June and July going over all our plantations and taking out the pine weevil. We are planting about half and half red pine and white pine. Some of our plantations are 25 to 30 ft. high, and are high enough to shut out all the underbrush, and certainly look encouraging. It is very interesting work and one, I think, that will not only bring profit but also the advantage of covering our watershed with trees which have beauty as well as a practical use.

MR. WILLIAM F. SULLIVAN.* Mr. President, Nashua is in Hillsborough County, New Hampshire, and this section of the state is a natural white-pine region. At the present time, on account of the browntail moth and gypsy moth, the stunted growth of deciduous and particularly of oak trees, and the long time it takes oak trees to mature, we do not consider the hardwoods of any especial value.

Our chestnut lots are affected with the chestnut blight, and we have been told by the state forester that we should cut all chestnut trees that show any signs of infection. I might say that our forest reservation was started about sixty-two years ago, when the water company first acquired land. And the water company has continued to acquire land ever since, primarily as a protection to its water supply. On some lots acquired, there were even stands of pine, some full grown. Other lots were sprout land, and some were pasture lands. We have done some planting on cut-over land. The planting was done not from seed, but from natural reproduction nurseries. From these nurseries we obtained the

* Engineer and Superintendent, Pennichuck Water Works, Nashua, N. H.

saplings, and planted them in open areas and on former grazing land. For years the company has thinned out and taken care of its forests, so that to-day we have arrived at the stage of being able to do lumbering operations. When we cut, we do it so that the cut-over strip will be to the southeast of full-grown stands or seed trees. As you undoubtedly know, this is for the purpose of having the seeds blow to the deforested tract, and if they take root there, seeds will reproduce naturally. We have some excellent examples of natural reproduction.

We are at the commercial stage of forestry. We have erected a water-power sawmill about midway of our reservation. We use our own men entirely in the operations from "stump to stick." We consider it profitable to use our regular crew in winter when very little pipe laying is being done, and thus keep our organization throughout the year. We may probably have some advantage over my friend from Hartford, and possibly some others, in that our foreman and laborers came from over the Canadian line, where in their youth they worked and logged in the woods, and are familiar with woodcraft. They are natural foresters.

For several years we have sawed our logs. This logging has been white pine and hard pine. The hard pine in our country is stunted in growth and not of as much value as white pine, but it makes good box boards, and we get a fairly good price for it. We have white pine of different grades, a large percentage being of first quality.

I will say it is my opinion, my strong conviction, that the planting of white-pine trees on land where they will grow, or the purchase of tracts which are coming up to pine, is a profitable venture, and will show a profit not alone for water companies, but for the farmer, for the firm, and for the individual. It is a proposition for any one with either large or small capital who is willing to let the investment remain over for a long period of years. By such an investment in white-pine growths, one is only putting the money so invested, with its increment, away for his children or his children's children.

Mr. Saville. I would like to say, Mr. President, that I personally agree with Mr. Sullivan that white pine is proper to grow on watersheds, and will perhaps warrant making it a commercial

success. At Hartford we are planting twenty-five acres a year, and expect to do it right straight along.

MR. SULLIVAN. Mr. President, the principal part of our reforestation is done by natural reproduction and from transplants from reproduction nurseries, as we call them. We have some excellent stands of transplanted white pine, from ten to twenty years of age, which are surprising. When trees show a diameter of 6 in., breast high, after twenty years growth, you will realize that white-pine trees have a value.

I will say regarding fires that we have been fortunate. We take the precaution to keep the slash and brush cleared and burned. The fire hazard in forests is not so great now as it was a few years ago. People in general realize the danger and loss there is from forest fires. The railroads are more careful. Sportsmen are careful after using matches and smoking. We maintain a patrol on Sundays and holidays. We have a private telephone from the pumping station to the center of our tract to enable the patrol to report any fire and call for help to extinguish it. We are also protected by wise forest fire regulations.

THE PRESIDENT. Is it not true, Mr. Sullivan, that you have built some roads through those woods which also tend to act as fire cut-offs?

MR. SULLIVAN. It is our purpose that all forest roads, in fact all roads through our land, should serve as fire stops. Logging roads which grow up with brush we plow and harrow so that there may be fresh earth. We have sixteen hand fire extinguishers ready and handy in an accessible place. We have an automobile truck in use for service work. This truck is provided with seats similar to the regulation fire patrol and is capable of taking on the extinguishers, shovels, etc., and a gang of from five to fifteen men. We have not had many fires, none serious, but our outfit has been of assistance to our neighbors, and by assisting them we have protected ourselves.

MR. WILSON FITCH SMITH.* Mr. President, in regard to the cost of planting, I might quote the experience at Kensico Reservoir. The city of New York has planted over 800 acres on the marginal strip around Kensico Reservoir during the past four

* Division Engineer, Board of Water Supply, New York City.

years with white, red, and Scotch pine and Norway spruce. In 1912 and 1913 the work was done by the employees of the Board of Water Supply. Three-year-old transplants obtained from various nurseries were planted in rows 6 ft. apart each way. During these two years, 551 000 trees were planted at an average cost of $12.38 per thousand. This cost includes the following:

	Average for Two Years per Thousand.
Cost of three-year-old transplants	$4.41
Freight on transplants	.43
Labor handling for inspection, and teaming	.50
Labor planting	6.30
Engineering supervision	.74
	$12.38

The labor was at the rate of $2.00 a day for an eight-hour day. These figures are the averages for two years' work. Toward the end of each season the men became more experienced, and planted about 500 trees per man-day.

For the purpose of obtaining well-grown stock for ornamental planting in conspicuous places, the Board purchased about 120 000 three-year-old transplants and put them in a nursery where they were cultivated for three years. At the end of that time, they were six years old, and were from three to five feet high, depending on the varieties, and their complete cost amounted to $60.52 a thousand. The same sized stock in a commercial nursery would cost from $125 to $300 per thousand at the nursery. Last spring 26 000 of these trees were lifted and planted out in permanent locations, at a cost of $73.91 per thousand for all labor, superintendence, and transportation over an average haul of two and one-half miles. Therefore the trees in their permanent position cost 13½ cents apiece.

Mr. Clapp. My paper was not prepared in any sense in the nature of a discussion of Mr. Culyer's paper, and I hope you will bear with me if in any connection I have contradicted any of the statements made by him. Mr. Culyer speaks of the very lavish hand with which the work of the Board of Water Supply was carried on, and the expense, but I think when you stop to think

of it, that a great deal of our planting has been at a profit to the contractor, at a price somewhat less than $26 to an acre, — resulting in the planting of 1 250 trees to an acre, which are guaranteed to grow. I do not think you will consider that very lavish.

MR. E. R. B. ALLARDICE* (*by letter*). About twenty years ago, during the early development of the plans for building on the South Branch of the Nashua River, at Clinton, Mass., what is now known as the Wachusett Reservoir, in which to store water for the supply of Greater Boston, the Metropolitan Water and Sewerage Board, largely through the efforts of its present chairman, Dr. Henry P. Walcott, appreciated the fact that, unless systematically and scientifically studied and developed, the marginal lands of this great inland lake would become waste and valueless, a detriment to the purity of the water supply and a menace to the life of the soil. The watershed area tributary to this reservoir covers about 118 square miles, of which about 7 square miles bordering on the immediate shore of the reservoir and extending along the principal tributary streams are owned by the Commonwealth and are controlled by this Board. This area has been developed along the lines of modern forestry from a pre-arranged plan outlined by Prof. J. G. Jack, of the Harvard Agricultural School, who made a study of the existing condition of the various kinds or classes of land, and outlined a general scheme to be followed, whereby the most economical use could be made of the land, and at the same time preserve and increase the purity of the water supply, protect the land against damaging floods, increase the duration of heavy yields, and preserve the usefulness of the soil.

In entering upon this work, the promoters did not have the advantage of others' experience. Although forestry, as forestry alone, had been practiced successfully for years, it remained for this project to make of it an important branch of the modern large water supply. Therefore, the first question to be decided was: How can this large area of land be reforested, to secure the most satisfactory results, without affecting, to the slightest degree, the paramount purpose of securing a pure water supply?

The problem presented an area made up of arable lots, pastures, timber stands, and sparsely grown sprout lands, which offered a

* Superintendent of Wachusett Department, Metropolitan Water Works, Boston.

splendid opportunity for the practice of modern forestry. The more hardy sprout lands and timber forests could, by the expenditure of comparatively small amounts, be made paying property by making improvement thinnings in them.

As the result of his investigation, Professor Jack recommended that the entire unforested portion of the reservation be planted with native white pines, making a self-perpetuating forest, which would ultimately provide a complete ground cover, requiring no artificial fertilizing or disturbing of the soil, and which would protect the waters of the basin from the direct contamination of manurial matters and soil washed from adjacent farms during heavy freshets or spring floods. The white pine was selected because of its almost universal adaptability to the various kinds of land and growth to be treated, its freedom from leaves, its rising value in the lumber market, and the ease, low cost, and comparative certainty of raising to maturity.

The general policy adopted comprised the raising of seedlings in nurseries established for the purpose; planting all the arable pasture, and light sprout land; underplanting and interplanting the thick sprout and young thinly grown timber land, and making improvement thinnings later as the growth demanded; improving the original timber stands; protecting the entire reservation with a 40-ft. marginal fire guard, internal 15-ft. access roads and a 50-ft. clearing along the shore line of the reservoir. During the first few years of this development, the plantings comprised white pines planted 10 ft. by 10 ft. apart, using oaks, chestnuts, and maples as fillers, making the final stand with trees 5 ft. by 5 ft. apart. This type of planting was used in arable, open pasture, and light sprout land.

There is a truism which says, "Progress is born of experience," and this has been proven to us in our experience with the hard-wood fillers. While the success with the white pines has been extremely gratifying, the failure of the hard-wood fillers to make even a creditable showing has been correspondingly discouraging. Consequently, after the first few years, the composition of the plantings in arable, open pasture and light sprout land was changed to a solid stand, with trees 6 ft. by 6 ft. apart. With this close spacing it is expected, and, in fact, is evidenced at this time, that the

limbs will interfere with each other and accomplish the same clearing of the trunks as was expected of the hard-wood fillers. In the thick sprout and young, thinly grown, timber land the pine seedlings were used to underplant the sprouts and interplant the open areas of the timber land. When planted in this kind of land the pines grow up in a rather delicate condition, until their tops encounter the low-lying limbs of the surrounding growth. At this stage it is necessary to give them assistance if they are to survive. This we have found can be done for about eight dollars per acre, the method being to cut out all growth which is in any way, at this time or within the next few years, liable to stunt or kill the trees. Our experience has shown that in stands of this type it becomes necessary to make a second clearing after a lapse of about ten years. Undoubtedly this is the last help the pines will require until they are about thirty years of age, when an improvement thinning will in all probability be made. In doing this work, due care is taken to preserve all valuable specimens of trees and to leave sufficient fillers of any nature whatever which will act as crowders to the pines.

Of the 4 667 acres, or approximately 7 square miles, of marginal lands, 1 313 acres have been planted to white pine and 852 acres of this area have been thinned once; while a very small per cent. has required a second thinning. In about 300 acres of the natural timber land, improvement thinnings have been made where the receipts from cord wood, ties, and fence posts have about covered the expense. There remains some 600 acres yet to be planted to white and red pine and spruce, which are being raised in our own nurseries.

During the early years of the work all trees were raised in nurseries of our own, while for a few years back several hundred thousand one-year seedlings have been furnished us gratis from the Department of State Forestry. These trees were set out in our nurseries in transplant rows, where they remained two years before they were planted in the field. No distinction has been made between spring and fall plantings, and both have been equally successful.

The following examples show the cost of planting and thinning under widely differing conditions:

(Minimum wage rate, $2.50 per 8-hr. day.)

29.6 acres of very rough scrub, sprout, and weed grass, preliminary clearing, March, 1908	$41.00
Planted in the fall of 1908 with 29 300 three-year-old white-pine seedlings, placed 6 ft. by 6 ft., these seedlings being one year in the seed beds and two years in the transplant beds.	
Raising stock in nursery	205.00
Planting in field	330.00
First protective clearing, December, 1911	330.00
Second protective clearing, March, 1915	304.00
Total	$1 210.00
Received from cord wood in 1911	20.00
Net cost	$1 190.00

Cost per acre to date, $40.00.
Estimated number of trees, 900 per acre.
Cost per tree to date, 4 cents plus.

20.3 acres of old pasture and run-out grass land, preliminary clearing	None
Planted in the spring of 1903 with 9 480 three-year-old white pine seedlings placed 10 ft. by 10 ft., these seedlings were one year in seed beds and two years in transplant beds.	
Raising stock in nursery	$67.00
Planting in field	193.00
Protective clearing, December, 1908	66.00
Total	$326.00

Cost per acre to date, $16.00.
Estimated number of trees, 400 per acre (standing).
Cost per tree to date, 4 cents plus.

FIRE PROTECTION.

It is needless to say that the greatest menace to the forests which we have to provide against, and the one which reqtires eternal vigilance on the part of each and every employee and all having the interests of the forests at heart, are the forest fires. To prevent their spreading to or from abutting property and to provide a line of defense on which to fight them, a fire guard, 40 ft. wide, has been cut around the entire outside limit of the marginal lands of the reservoir. There is also a network of "forest roads," 15 ft.

wide, throughout the reservation, which acts as supplementary fire protection. The brush and weeds are cut from these two protective systems every alternate year.

On holidays and Sundays during the dangerous seasons of the year (early spring and late fall), men armed with fire extinguishers patrol the reservation to further protect it from the ravages of forest fires. Of late years a motor drawn and operated power-sprayer truck with a capacity of 400 gal. has been added to the equipment and has done very efficient service both in extinguishing fires on our property and in stopping them at the fire guard when approaching from abutting property. Too much emphasis and praise cannot be given to the forest lookout, stationed as he generally is on top of some lonely mountain or hill, for the very efficient and invaluable service he renders in locating fires and summoning assistance.

In the years 1911 and 1912, four forest fires destroyed the pines on an aggregate of about 125 acres. These trees were from eight to twelve years old, and it is needless to say were among the finest stands on the reservation. The cause of these fires were traced to a cigarette butt thrown from a passing electric car, the presence of berry pickers (smoking) on the reservation, and from sparks from a locomotive. From the latter cause we have very frequent fires, and while we experience no difficulty in reaching a satisfactory financial settlement for damages, yet it does seem that some actioh should be taken whereby the present laws relative to protective devices on locomotives be enforced.

Of late years the forestry plans have been extended to cover the large holdings surrounding the Sudbury storage reservoir and the numerous small distributing and compensating reservoirs scattered throughout the Metropolitan district.

The writer having had no part in formulating the plans for the work herein described, nor in the working out of the plans in their early stages when the success or failure of the venture was in the making, feels that he can, without undue boastfulness, emphasize the success of the work as a whole and the favorable comments heard by visitors from all over the world, and especially by the forestry experts from the United States Government. There are stands of pine now about fifteen years old, on the old spacing of

FIG. 1.
WACHUSETT RESERVOIR EIGHT-YEAR-OLD WHITE PINES PLANTED IN SPRING OF 1903 ON TEN BY TEN FOOT SPACING.

FIG. 2.
WACHUSETT RESERVOIR. TWELVE-YEAR-OLD WHITE PINES.

10 ft. by 10 ft. and about eleven years old on the new spacing of 6 ft. by 6 ft., where there are living to-day 95 per cent. of the trees set out, and which have grown so as to provide a complete cover, and which will require the first improvement thinning within a year or so. It is a common sight to find trees which have grown from 2 to 3 ft. a year with a 6-in. butt, and it certainly is very pleasing and gratifying to be told by men who make a study of this subject and travel all over the world in so doing that nowhere in the United States is there such a fine showing. Certainly the Commonwealth of Massachusetts is to be congratulated upon being, through the Metropolitan Water and Sewerage Board, the pioneer in making so important a subject an adjunct to the large municipal water-supply systems of to-day, and to have set the example which other states in the Union have seen fit to emulate in this same connection.

DOUBLE SAND FILTRATION OF WATER AT SOUTH NORWALK, CONN. — REMOVAL OF ORGANISMS, TASTES, AND ODORS.

BY HARRY W. CLARK, CHEMIST MASSACHUSETTS STATE DEPARTMENT OF HEALTH.

[*Read September 7, 1916.*]

South Norwalk is a city of about 10 500 people, situated on Long Island Sound, forty-two miles from New York. A public water supply was introduced in 1876, and this supply has been enlarged from time to time by the acquirement of various new sources and the construction of new reservoirs. The total population supplied is about 13 000, other communities than South Norwalk receiving this water. The water system includes ten square miles of watershed, 500 acres of land, and four reservoirs with a capacity of 700 000 000 gal. The two principal reservoirs are City Lake Reservoir and Rock Lake Reservoir. The consumption of water is large for the population supplied, averaging about 2 500 000 gal. daily, or about 200 gal. per capita. Few meters are installed.

The water of the South Norwalk reservoirs has through many years been subject at times to enormous growths of taste- and odor-producing and other microscopic organisms. Asterionella, Anabæna, Dinobryon, Aphanizomenon, etc., flourish very vigorously at certain periods, sometimes singly and sometimes together. These growths are generally greatest in the months of August, September, and October, but occur at other times also. Growths of certain of these organisms are prominent as a scum at times on the surface of considerable areas of the main reservoirs. Samples of water shipped to me in the summer season from City Lake Reservoir have occasionally been long enough in transit for the disintegration of these microscopic growths to have occurred and to give the water the intense, vile, pigpen odor caused by this disintegration and decay. Cities are slow to act, and a long-suffering public put up with the tastes, odors, and generally dis-

agreeable conditions of the water supply through many years. Improvement was earnestly desired by the water commissioners and the citizens. Various mayors recommended action in different inaugural addresses, and in January, 1905, Mayor Dow, speaking of the filtration works then under construction, stated: "We who have suffered from the water conditions as they have prevailed can appreciate fully what filtration will mean.' Previous to this, in March, 1904, the speaker was retained by the South Norwalk Water Commissioners, Messrs. Stephen Hatch, Christian Swartz, and Franklin Smith, working in coöperation with a special water committee, to advise in regard to improvement of the water and filtration. The water question was studied and double sand filtration recommended. Some experience with this water several years earlier than 1904 and the results of filtration investigations upon the water of Ludlow Reservoir, Springfield, Mass., were the foundation of the advice given.

At Ludlow Reservoir, the old water supply of Springfield, filtration investigations for the Massachusetts State Board of Health and the Springfield Water Board, carried on largely under the direction of the writer during the year 1901, had shown that water from a shallow reservoir containing at times enormous growths of Anabæna and other taste- and odor-producing organisms, together with much organic matter, iron, and color, could be rendered entirely satisfactory and free from tastes and odors by aëration and double sand filtration.

At Springfield, the primary experimental filters were operated at a rate of 2 500 000 gal. per acre daily and the secondary filter at a rate of approximately 10 000 000 gal. per acre daily. This experimental plant removed not only the organisms and the tastes and odors, but caused a very substantial reduction of the iron, organic matter, and color of the water so treated. In fact, during the four months of the year when the applied water was highest in color, the filter removed 63 per cent. of this coloring matter. With the results of this Springfield investigation as a precedent, the writer had little hesitation in recommending a double sand filtration plant for South Norwalk, and the results of nearly seven years' operation of the filters have been an ample vindication of the advice then given.

Briefly, the plan of filtration was to aërate the water thoroughly, then pass it through a filter containing about three and one-half feet in depth of coarse sand, then aëration and a second filtration during that portion of the year when the water was in its worst condition. Rates similar to those successful at Ludlow were planned for; namely, 2 500 000 gal. per acre daily for the primary filter and 10 000 000 gal. for the secondary filter. The object of this filtration was, let me make it clear, not the improvement of the water bacterially, although, of course, this followed, but the change of a water at times almost entirely unsuitable for domestic consumption, owing to its disagreeable qualities, to one entirely satisfactory in every respect. Just how bad the water in the city was at times before the filters were installed, I have little personal knowledge. I understand, however, that for considerable periods of each year the taste and odors were decidedly rank and the turbidity of the water very noticeable. On several occasions when visiting the filters in the summer season since their construction, the water over the primary filter has, owing to the organisms present, looked like a thick green pea soup. It is a fact, moreover, that the water board of a certain Massachusetts city visiting South Norwalk on a tour of inspection became decidedly opposed to filtration on account of the strong odor at that time around this South Norwalk filtration plant. They could hardly be persuaded to look at the improved water after filtration, apparently deciding that a filtration plant would be a nuisance. William S. Johnson, C.E., of Boston, was associated with the writer in preparing the designs of the filters, and to him much of the success of the work is due. Samuel W. Hoyt, C.E., of South Norwalk, was in direct charge of construction, and the Bunting Construction Company were the builders.

The filters are located about 1 000 ft. south of the city's largest reservoir, known as City Lake, and water flows from the lake to the filter through an 18-in. pipe. City Lake is about 260 ft. above the city level, which is practically sea-level. The filters were built during 1906 and 1907 and were put into operation on June 22, 1908. They are of concrete construction and covered. The primary filter is divided into three sections, each 78.4 ft. wide and 145 ft. long inside measurement, slightly more than 0.25

acres; the floor is 15 in. thick under the piers and 6 in. midway between. There are fifty piers in each section, 28 in. square at the base and 20 at the top. The concrete roof is of groined-arch construction, 6 in. thick at the summit of the arch. It is not reinforced. Each span is 11 ft. 8 in., and the arch is half an ellipse with a rise of 2 ft. 6 in. There are thirty manholes in each section. Near the center of the floor of each section an effluent channel is placed, 2 ft. 10 in. wide and 8 in. high, covered with reinforced concrete slabs. From this main channel, lateral lines of 10-in. split vitrified pipe are laid in the invert of each vertical curve across the filter beds. The underdrains are covered with 14 in. of graded gravel. The sand in each filter is 3 ft. 9 in. deep and of an effective size of from 0.35 to 0.38 of a millimeter.

No sand could be discovered within about seven miles of the filter and the railroad was many miles away. There was, however, a gravel deposit just a mile distant across country, and we finally, after extended investigations, decided to use the sand contained in that gravel. To obtain one yard of sand it was necessary to handle something more than three yards of material, and the screening was all done by hand, as the circumstances were such that it did not seem to be economical to put in a mechanical screen. Then a new road, a mile in length, was built across country and the sand was hauled to the site of the filter. After reaching the filter it had to be washed to remove the fine material and dirt, taking out about 5 per cent. in the process. The cost of the sand placed in the filter was about $2.45 per yard.

The washing at this place was of necessity done inside of the filter, as the wash-water was obtained by gravity from a reservoir, and the head was not sufficient to deliver any considerable quantity of water above the roof of the filter. At first we thought the location of the washing apparatus inside of the filter was going to be a disadvantage, but it proved to be the opposite.

The sand was dumped through one of the manholes into a hopper which fed directly into the washer, and the dirty water was carried off through one of the drains. The clean sand was discharged into wheelbarrows on a plank run, and a constant stream of wheelbarrows passed the outlet of the washer.

The water comes to the primary filter through an 18-in. pipe

and passes to the aërator placed in a concrete aërating chamber. The aërator is a steel box 9 ft. 3 in. long, 6 ft. 6 in. wide, and 4 ft. high. It has 6 836 holes $\frac{3}{16}$ in. in diameter spaced 1 in. between centers. This form of aërator was adopted after various experiments made by me at the Lawrence Experiment Station in regard to the quickest and most thorough method of introducing air into water free from air; that is, water that, owing to the presence of much organic matter in a state of change, had exhausted the free oxygen normally present. It was found by these experiments that even weak sewage devoid of oxygen could be nearly saturated with air when dropping from a box of this description through $3\frac{1}{2}$ ft. of air. The small streams coming from these $\frac{3}{16}$-in. openings, twist and break and the water becomes a white-foaming mass, about 6 in. below the aërator pan. The aërator is regulated by a float valve.

The water after passing through the primary filter collects in a central effluent channel and flows to four 14-in. Venturi meters, one for each section of the primary filter and for the secondary filter. These meters register and record the rate of filtration, the elevation of water in each bed, and the loss of head. From these meters the water passes to a central chamber under the operating house, and from there it may be passed to a secondary filter or to the city mains or to a clear water reservoir with a capacity of 250 000 gal. The secondary filter is of the same design, construction, and dimensions as each section of the primary filter.

In the operation of the experimental filter at Ludlow one phenomenon was noticed that occurs often with the primary filter at South Norwalk; that is, during the period of each year when the organic matter or organisms are in the greatest abundance in the reservoir water, the quick oxidation of this organic matter in the sand filter causes a complete exhaustion of the oxygen, and the remaining unoxidized organic matter then takes oxygen from the iron and manganese oxides in the sand, iron and some manganese hence coming through in solution. While this adds to the load of the secondary filter, this iron and manganese is thoroughly oxidized by aëration before reaching the surface of the secondary filter and hence acts as a precipitant, and the secondary filter removes more organic and coloring matter at such times than

during other periods of the year. The question may be asked whether this action could not be avoided by passing the water more rapidly through the primary filter and thus not giving time for oxygen exhaustion. This might be done except for the load of organisms occurring at these periods. Attempts were made at Ludlow to overcome this trouble by the operation of a filter with a shallow depth of sand, and while this was more or less successful, it did not entirely obviate the difficulty.

At the Ludlow experimental filters the primary filter caused a very satisfactory removal of tastes and odors until Anabæna became very abundant in the applied water, the number of organisms of this kind reaching at times nearly eleven thousand per cubic centimeter, and at such periods the effluent from the primary filter had decided tastes and odors, these tastes and odors being, however, entirely removed by the secondary filter operating at a 10 000 000 rate, and this is very largely the experience at South Norwalk.

Owing to the level of the filter being nearly that of the reservoir from which water is taken, the lack of water pressure for the operation of the customary sand-washing machines has caused some difficulty in washing the sand economically. Generally, sand washing is carried on as follows, the sand being washed in place. Water enters at special inlets at the filter's surface and it flows over the sand controlled in fairly narrow channels by wooden baffles placed in the sand. The sand is disturbed by rakes, and the accumulated material, dirt, etc., is washed across the bed to specially designed waste drains.

The filter throughout the seven years of its operation to date has been entirely satisfactory and successful in accomplishing the object for which it was constructed. Organisms, tastes, and odors are completely removed, together with at least 50 per cent. of the coloring matter of the water, the apparent color removal being much greater than this. According to South Norwalk physicians, it has also had a beneficial effect upon the health of the community, but I have no statistics upon this point. The cost of this plant with a total filtering area of one and one-fourth acres was just about $100 000. The statistics for the year ending May 1, 1915, are as follows:

SOUTH NORWALK WATER WORKS, JUNE 15, 1915.

Yearly Report at Purification Plant for the Year ending May 1, 1915.

Total number of gallons of water used	923 256 331
Daily average for year was	2 529 469
Greatest amount filtered on one bed between cleanings	37 095 370
Least amount filtered on one bed between cleanings	2 508 545
Greatest amount filtered on one bed per acre	148 381 480
Least amount filtered on one bed per acre	10 034 180
Total operating cost without supplies	$4 335.20
Operating cost per 1 000 000 gal. filtered	$5.23
Average amount filtered per cleaning, gallons	11 398 229
Number of times secondary filter was cleaned	9
Longest run on secondary filter	93 days
Shortest run on secondary filter	9 days
Greatest amount used in 24 hours (Dec. 29, 1914)	3 125 485
Least amount used in 24 hours (Oct. 25, 1914)	2 087 615
Average rate of filtration of primary filter, gallons	3 300 000
Average rate of filtration of secondary filter, gallons	10 000 000

DISCUSSION.

MR. JAMES S. DUNWOODY.* I would like to ask Mr. Clark if he has any temperature data, especially for the summer months? I understood him to say that this Asterionella lasted throughout the entire summer.

MR. CLARK. I never noted the temperature the water reaches at the time when these organisms begin to be prominent at South Norwalk. The reservoir there is quite shallow and I have no doubt the temperature gets very high. They may have some data there. I may say that I have had very little to do with this filter plant during the six or seven years since its construction. They have been able to run it satisfactorily themselves, and it has not been necessary to call me in but once or twice to help a little.

MR. DUNWOODY. Do I take it this lake is formed by springs?

MR. CLARK. No, I should say not. It comes from brooks quite largely.

MR. DUNWOODY. With what experience I have had with this algae, it never lasts a full season to much extent unless the temperature of the water is kept quite low.

* Erie, Pa.

MR. CLARK. I have had quite a different experience. I have seen algae last through many weeks of high temperature. The reservoir at Ludlow, which is a shallow reservoir with stumps of trees sticking up through the water, has high numbers of organisms through the warm months of August and September. Whether it appears at one temperature or another depends altogether on the kind of organism.

MR. DUNWOODY. In our water supply at Erie we are troubled considerably with the Asterionella. Our temperature in the winter time gets very close to freezing, 33 to 35 degrees, and in the summer as high as from 70 to 75 degrees, but it is at what you might call the period of the lake turnover that we are most seriously affected by the growth.

This last year was the worst season we have ever had. The period lasted nearly two months, from May first to July first, but when the temperature of the water reached above 55 degrees we had a very sudden, practically complete, disappearance of the Asterionella.

MR. CLARK. At the present time [September] the temperature of the water at South Norwalk is, I suppose, as high as it gets during the year. I don't know what its temperature is, but the City Lake Reservoir is now a nice green color through growths of Aphanizomenon, — not odor-producing except by decay, but it is very thick in the water at the present time, and of course clogs the filters as much as any organism.

MR. ALLEN HAZEN.* I think the author deserves our commendation for his part in producing one of the most complete plants for removing tastes and odors that has ever been built. And it is also well that this paper has been presented now because it calls attention to a very important problem in treating waters to improve their physical properties, by removing tastes and odors. That is one of the things that I have had the pleasure of talking to the Association about from time to time in years gone by until you must be tired of hearing about it. But it is something I believe in very thoroughly. Treating water for disease-producing properties is all well enough, but it is very important to remove these objectionable qualities, and none of these are more bother-

* Civil Engineer, New York, N. Y.

some than tastes and odors, and it is very well worth while to spend the necessary money, which, after all, is a comparatively small amount, and clean up the water until the tastes and odors disappear, and to make it just as attractive in every way as spring water. This is something that has been done in a few cases and it needs to be done, and I feel sure is going to be done, in a great many others.

MR. S. S. HATCH.* I am nothing of a chemist; I know nothing of chemistry. But we have a very efficient man at the filter, and I can say to you that the filter not only takes away the odor and the taste, but all our doctors in South Norwalk tell me that their incomes have been reduced at least $20 000 per annum and that they have nearly forgotten how to take care of bowel complaints, they have so few of them in South Norwalk. One of the druggists said that the call for bowel medicines had stopped on account of this filter. Of course we have no fear at all of typhoid.

We are very careful in the management of the filter. The original cost of it was about $100 000; the houses that the men live in and other improvements added $20 000 to the cost of the plant. The interest and the expense all told is about $10 500 a year; less than 90 cents per capita per year. We did not make any change in the rate for water on account of it. We have a small net income from the plant.

MR. DANIEL D. Jackson.† The percentage of wash water to wash the filters is what?

MR. HATCH. At the present time we are raking the sand and are using raw water; as we have plenty, we do not measure the amount. It comes in by gravity and is kept about 4 in. deep. The men rake the sand, the scum rises and flows off in a quick current. We use a dashboard. Perhaps the opening will be, between two columns, 12 ft. It makes a very quick current and goes out into a drain. In the spring the sand that has been taken out (about 1 500 yd.) is washed in a washing machine and replaced. We stop raking in October. We have a little box, about 10 ft. square, high enough to give us pressure, and that water is cleaned through the sand in that box. The water in the reservoir

* Water Commissioner, South Norwalk, Conn.
† Of Columbia University, New York.

at that time is in pretty fair condition. It is in March, right after the ice gets out of the sand, that we wash and return it. I think we take about 200 000 gal. of water per section for washing, by raking, but it is not filtered water. The machines use about 100 gal. per cubic yard of sand.

Mr. L. M. Hastings.* I would like to ask about cleaning the sand in the filter. Have you any idea, Mr. Clark, how much water it takes for washing the sand? Either in gallons or per cent. of water filtered?

Mr. Clark. The sand is washed as follows: Water flows into each section and is flushed across the surface of the sand while the sand is being stirred by rakes in the hands of workmen, and then goes out through a drain on the other side of the filter, carrying the dirt with it. There are baffles placed across the sand so as to make a fairly strong current of water over the section of the filter being washed.

The frequency of washing depends altogether on the quality of the water going through. I think that the shortest run was something like eleven days in 1915. The longest was perhaps five or six times that amount.

The water is really of no value that they use in cleaning. It is the reservoir water, and they always have enough. They don't use filtered water. We do not know how much water is used for washing.

Mr. Allen Hazen. I can answer some of the questions from our experience in operating several plants. They have been running for the last few years, and the water used for washing the sand usually runs from one fourth to one half of one per cent.

Mr. J. M. Diven.† In the southern states algae troubles last for much longer periods than in the cooler climate of the North, as the cold weather either kills them or causes them to seek shelter in deep water, where they do not cause much trouble, just spend the winter multiplying and preparing to give trouble when the warm weather comes. At Charleston, S. C., where the supply is an impounded surface water, they were active for nine or ten months

* City Engineer, Cambridge, Mass.

† Superintendent of Water Works, Troy, N. Y.

each year, some years failing to take any vacation, keeping on the job the entire year.

In one case, in a northern city, the trouble came so suddenly and the water got so bad that it was impossible to operate the mechanical filters, as they clogged up faster than they could be cleaned, and the filter tubs, rakes, etc., became plastered with a sticky and stinking mass. The men who attempted to operate the mechanical rakes to keep the filter beds opened were nauseated and unable to attend to the work for more than a few minutes at a time. Asterionella and Anabæna were the principal offenders in this case.

Mr. Jackson. My question regarding the wash water had reference to some experience which we had in the Department of Water Supply in filtering water containing large amounts of algae. We had on one of our filters a very large growth of algae, and we tried the treatment with copper sulphate. The amount of wash water which we were using at times for the plain filtration of that water ran as high as 25 per cent., a practically impossible amount to use. It often ran as high as 8 and 10 per cent., due to the thick growths which occurred in the pond from which we were filtering the water. Now, it would be perfectly feasible to filter a small amount of water, water containing a small amount of algae, either by sand filtration or by mechanical filtration. But when it comes to very heavy growths, operation under very bad circumstances may completely stop. So we were obliged to use copper sulphate in connection with filtration. And on one occasion, when the wash water ran as high as 25 per cent., we added copper sulphate to the pond, and in the course of a few days the wash water dropped down to about 3 per cent., which was the normal amount. The point which I wanted to make was that on many waters it would be impossible to treat by filtration, either by slow sand or mechanical, without also the accessory use of copper sulphate. I would like to ask Mr. Clark if copper sulphate was necessitated at South Norwalk at any time.

Mr. Hatch. The experiment with copper sulphate was made at two different times in one year, — in the early season and about October. We found our filter clogging in about six days, the algae growth was so heavy. We tried it once and we had a very ludi-

crous effect. It killed a few fish in the pond, and people thought that everything was polluted. They called it a cesspool, and at one of the factories said they found the copper in their chemical solution. Mr. Newland, state chemist, could find no trace. So we never tried it again, but when we did use it the filter ran twenty days instead of six without cleaning. But now we spend the money in labor instead of using the copper.

MR. DIVEN. Mr. Clark, what was the number of algae in the water?

MR. CLARK. I don't know. I have had several samples that ran up to thirteen or fourteen thousand to the cubic centimeter. I think this organism found the other day was five or six thousand per cubic centimeter, — very thick, very green. It looked like a green pea soup.

MR. DIVEN. The speaker agrees with Mr. Jackson that water may be so heavily impregnated with algae that it would be impossible to treat it by that process, as the filters would clog up faster than they could be raked, even if men could enter and remain in the chambers to operate the rakes. The stench from some forms of algae would make this almost impossible.

MR. CLARK. I have had experience only with reservoirs at Ludlow and South Norwalk. Sand filtration seemed to go all right at these places.

MR. DUNWOODY. That was the experience we had with the Asterionella. The beds were not running more than two hours before there was a complete plugging up, and a wash was required. With a wash every two hours our wash water got up as high as eight per cent. We were right on the verge of using copper sulphate. We did not want to use it unless it became a necessity, and if the growth had gotten any worse we would have had to do it, but the conditions gradually got better from that time on because of the increase in temperature.

MR. HAZEN. It may be well to put on record that at the Ludlow reservoir, to which Mr. Clark has referred, the water, which is certainly as rich in algae as in almost any reservoir there is, was filtered successfully in the summer for quite a number of years through sand filters, and in that case no wash water or copper sulphate was used at all. The surface of the sand was raked and

sometimes strained, and it never received any other treatment. The filters are uncovered.

MR. WILLIAM WHEELER* (*with addition by letter*). In Winchester, Ky., the water was taken from an impounding reservoir built in 1890 on a creek in the fertile Bluegrass region of Kentucky where the underlying formation is of limestone. The reservoir, originally of only some thirty million gallons capacity, was increased, in 1894 and 1903, to about eighty-five million gallons. It has a watershed of about twelve square miles, from which the creek flow varies from torrential volumes following heavy cloud-bursts to scarcely measurable quantities at times in the driest seasons.

Odor and taste in the water first appeared appreciably during the hot summer months two or three years after the works were built, and continued in variable but usually increasing degrees thereafter. The installation in 1893 or 1894 of mechanical filters of the pressure type, supplemented by aëration, mitigated quite effectively the objectionable conditions in the water supplied, until 1901, when the odor of decaying organisms and their secretions became extremely offensive, — substantially all public water supplies in that region experiencing the same trouble. Better seasonal conditions in 1902, aided by further provision for aëration and for taking water where least infected with the offending organisms, made the service of that summer fairly acceptable.

A sample of the raw water collected early in September, 1901, and examined two weeks later at Boston by Horatio N. Parker, was found by him to contain very large quantities of Clathrocystis and Oscillaria, with much smaller numbers of Crenothrix and of various protozoa, and with minimum numbers only of Anabæna. Doubtless great changes in relative numbers of the different algal forms contained in this sample had occurred between the time of its collection and that of its examination, especially as it had been forwarded without icing or other thermal protection.

Conditions were somewhat less acute in 1902, and the effects of the algae yielded fairly well to aëration and filtration.

Early in 1903, on learning of the successful use in the South, of copper to rid watercress beds of Spirogyra, we secured the coöperation of the United States Department of Agriculture in making

* Consulting Engineer, Boston, Mass.

what appears to have been the first application of copper sulphate to prevent algal growths and to neutralize their effects in a reservoir for public water supply.

Algae first appeared that year in sufficient numbers to cause objectionable odor and taste on or about the first of July, and microscopical examinations made during the ensuing weeks — before applying the treatment — showed averages per cubic centimeter of, — Anabæna, 7 400; Clathrocystis, 1 100; and Eudorina, 200. The treatment was applied July 9, by placing copper sulphate in a coarse sack which, suspended from a rowboat, was drawn to and fro over the surface of the reservoir, giving especial attention to those parts which seemed to contain the largest number of organisms. There were then about 25 000 000 gal. of water in the reservoir, to which about 50 lb. of copper sulphate were applied, or at the rate of one part to 4 000 000.

Counts from surface samples showed the quick effect of the treatment upon the number of filaments of Anabæna Flosaquae thus:

	Filaments per c.c.
July 6 (before treatment)	3 400
July 10 (after treatment)	54
July 11 (after treatment)	8
July 13, 15, and 20	0

Meanwhile the original closed or pressure filters had just been replaced by a new and larger installation of mechanical filters of the gravity type, with simple appliances for some incidental aëration of the water as it was discharged from the coagulation basin into the filters.

After treatment the water in the reservoir soon cleared, and as filtered and supplied to consumers was substantially free from odor during the remainder of the season. The following year, 1904, one application only of copper sulphate was given, as that sufficed to prevent a recurrence of the algal growths during the season. In that year, a second reservoir of about 105 000 000 gal. capacity was built on a fork draining about half of the same watershed. This reservoir has been less affected by algae, and has been treated less frequently than reservoir No. 1.

The records of the copper sulphate treatment from 1904 to 1909, inclusive, are incomplete, but it has been the practice to treat reservoir No. 1 each year on the first appearance of algae in significant numbers. During the last six years, 1910 to 1915, the first application has ranged from May 27 in 1911 to August 8 in 1910. The average time of first applications each year has been about June 18; and of the latest ones each year, when applied more than once, about September 2.

The number of applications in each year, — 1910 to 1915, inclusive, — most of which were dry years, — has ranged from one in 1913 to four in 1911 (rainfall in May, June, and July was 2.63 in., and in August 2.51 in.), with a total of sixteen in the six years. Four of these dosings were substantially lost or neutralized by rainfall and stream flows that immediately followed their application. The average dose was at the rate of one part to 3 000 000 of stored water. Under like meteorological conditions, there appears to have been very little, if any, progressive change in the amount of copper sulphate required from year to year.

The reservoirs have from the beginning been stocked with fish by a local fish and game club; and the superintendent reports that injurious "effect of the treatment on the fish has been noticed but once since the treatment was begun, which was in 1911, when some few were killed. These were of the new light or crappie species, and I attribute their destruction to the heavy dosing made along the edges. . . . The water is stocked with St. Mary bass, new lights or crappies, brim, and catfish, which have come in from the creeks. Each year the catfish die in large numbers at the spawning season in early May, but this occurred before the copper sulphate was applied."

REASONS FOR ADOPTING THE SOLID-WEDGE TYPE OF VALVE IN THE BOSTON WATER DEPARTMENT.

BY GEORGE H. FINNERAN, SUPERINTENDENT DISTRIBUTION BRANCH WATER DEPARTMENT, BOSTON, MASS.

[*Read September 8, 1915.*]

It is not my purpose, in this short paper, to enter into a detailed or technical discussion of the merits or demerits of either the solid-wedge or double-disk type of valve. Nor do I intend to particularize as to the various makes. That would be a very large task, because of the many kinds and great variety of mechanism. Furthermore, it would tend towards the identification of the valves, and that of course is not within the scope of this organization. I shall simply make a few general statements which I trust will show the principles that influenced the officials of the Boston Water Department in deciding to continue the manufacture and use of the solid-wedge type of valve.

A valve, as generally considered by water-works men, consists in the main of three parts, the casing or body, the stem, and the gate or plug. There appears to be a general uniformity or standard in the design of the casing and stem, but in the matter of plug or gate, for some reason or other, a number of the manufacturers have abandoned the old solid-wedge type of plug and have taken up with many and varied kinds of loose double disks with more or less complex expansion devices.

Some of the manufacturers produce more than one design of actuating mechanism. This fact might possibly indicate that there was doubt as to which design was the most efficient.

Whether or not the departure from the old solid wedge was the result of a demand on the part of the consumer for something different would be interesting to know.

While it might be inferred by the title of this paper that the adoption of the solid-wedge type of valve by the Boston Water

Department was of recent occurrence, as a matter of fact that type of valve has been in use since the present system of piping was laid in 1848, a period of sixty-seven years.

The Boston Water Department manufactures its own gates, hydrants, bronze fittings, etc. All its fixtures are made from its own special designs, and while in a general way they are similar to those used by various water works throughout the country, yet in detail they differ.

Recently, new sets of designs and patterns have been prepared for the manufacture of valves from 4 in. to 12 in. in diameter. The question of changing from the solid wedge to the loose double disk was considered, with the result that we adhered to the solid wedge with some slight modifications in its structure for the ultimate purpose of reducing its cost.

We were influenced towards this decision by several reasons, principal among which are the following:

Sixty-seven years of experience with the solid wedge has developed no convincing reason why we should discontinue its use.

No inherent weakness or objectionable characteristics have been observed during that time.

It has done its work satisfactorily. Whenever it becomes necessary to remove from service a gate with a plug of this type, it is usually because of some defect in a part other than the plug.

This good record of durability and satisfactory service of the solid wedge is nothing more than a demonstration of the proposition that in things mechanical, simplicity should be the preëminent characteristic, and it is only through that property that true excellence is attained.

The solid wedge can certainly lay claim to being mechanically simple, and it is in this quality that we find its greatest virtue.

It is claimed by those favoring the double-disk type of valve in preference to the solid wedge that with the former a double seating is assured when the gate is closed, with consequently increased tightness, and with very little frictional resistance on the way down.

In considering the merits of the respective types, we were impressed by the fact that there is practically but one seat to a valve

in operation, and that is the seat opposite to the side on which the pressure is. Hence the superfluousness of the second disk in the double seating plug of the expansion type.

Consider, for example, a closed 16-in. gate sustaining an unbalanced pressure of 100 lb. to the square inch. Here we have a stress of about 10 tons forcing the valve against its seat. Why not allow this great force to seat the wedge tightly instead of opposing it with a counter force generated by the expansion of the disks, as in the double-disk type of gate? I have serious doubts if under the conditions just described that a double-disk plug seats tightly on both sides. I have fears for the strength of the toggle or expanding device against such a tremendous strain. It may be that a gate of that type realizes its primary purpose more by being forced against one seat by the pressure than by closing against both seats through its own expansion, as it theoretically is supposed to act.

In a hydrant designed and built for the high-pressure fire service of Boston, the nozzles are controlled by bronze valves consisting of a single solid disk, loosely seated but closing tightly when the pressure is admitted to the barrel. Although these valve disks control an orifice only 3 in. in diameter, they prove the efficiency of the solid wedge by seating tightly through the force of an unbalanced pressure.

I am informed that in San Francisco they have advanced so far on the premise that there is but one seat to a valve in action that they are building a valve with parallel seats and a solid plug without a taper, thus depending entirely upon the pressure to seat the valve.

What moved us, furthermore, in this matter was the uncertainty of the double-disk type of valve overcoming rust and other solid matter that is generally encountered between the seats of valves infrequently operated, as against our ability to dislodge with the solid wedge an amount of such matter sufficient to allow of the tight closing of the valve by manipulating the wedge; that is, raising and lowering it and crushing and washing out the obstructing material. The horizontal movement of the expanding disks is more apt to drive the matter against the seats with such force as to adhere and prevent tight closing.

What also impressed us was the liability of the double-disk plug, by reason of its looseness when not seated, to vibrate during a quick rate of flow, water hammer, air pockets, or any other condition that would cause a disturbance in the main. The sound of this vibration might enter houses nearby and prove objectionable, but its serious possibility is the wear on the more or less complicated mechanism of the disks. I know of cases where the rings on the disks have been shaken off by vibration.

One of its weakest spots, in my opinion, is the opportunity for rust or other matter to accumulate between the disks and adhere to the various knuckles, hinges, wedges, trunnions, loose joints, etc., of the operating mechanism, clogging them and interfering with their action. In waters of heavy lime content, or those with a corrosive constituent, the effect would tend practically to put the valve out of commission.

While in theory it is very attractive to contemplate the loose double-disk plug descending without frictional resistance and upon reaching the bottom to expand to a water-tight bearing on both sides, yet it strikes me that such smooth action a great many times is in theory only.

In a large city where a gate is frequently operated and subject to rough usage by unskilled and indifferent men who are inclined to apply a surplus of energy to their work, a plain rugged type of valve is almost a necessity.

After an earnest consideration of the various points for and against both types, we felt that we could not very well improve on the simple, sturdy, and honest solid wedge that descends into its seat, filling the same tightly and performing the chief function of a valve, viz., the absolute stoppage of the flow. Without complex mechanism its very simplicity insured its durability and reliability of action, and its record of many years' service without defect or weakness confirmed its claim for all those good qualities.

The wisdom of changing from a fixture of proved satisfaction to one which possessed possibilities of uncertain performance seemed doubtful to us, hence our decision to continue with the solid wedge.

The object of this paper, however, is to elicit a discussion among the members present with a purpose of setting forth any good or

bad points in connection with both types of valve that have not been mentioned by the writer. I am sure that there are other angles from which this "wedge question" may be observed, and in the minds of those present there are possibly more weighty factors and convincing reasons why one type of valve is superior to the other.

(For discussion of this paper see page 110.)

REASONS FOR USING THE DOUBLE-DISK TYPE OF VALVE.

BY J. M. DIVEN, SUPERINTENDENT WATER WORKS, TROY, NEW YORK.

[*Read September 8, 1915.*]

The writer having had no recent experience with solid-wedge valves, in order to get some knowledge of them as now manufactured, referred to the catalogues of valve makers. Of the many catalogues consulted, three only listed and described solid-wedge valves, and these three manufacturers also made parallel seat valves. The solid-wedge type seemed, therefore, to be in a minority, so far as the manufacturers are concerned. The class of goods put on the market is a good indication of the demand, for manufacturers are always trying to meet the demand, and to manufacture what they can sell. The writer's personal knowledge of water-works practice is that comparatively few solid-wedge valves are used, and, as water-works men everywhere are looking for what is best, it does not seem that solid-wedge valves would have been overlooked or rejected by them if better than, or even equal to, the parallel disk type. The fact that a valve or other appliance has been used for a long term of years and has given satisfaction is not positive proof that something different might not be an improvement.

The writer has used the double, or parallel, disk type of valve because to him it seemed to be of better mechanical construction, to offer less trouble in operation, and less wear. In the operation of double-disk valves there is practically no friction, and such as there is does not come on the water-tight portion, but on the wedge nuts, where wear in no way affects the tightness of the valve.

The solid-wedge valve came to us from England in the early days of water-works construction, when we imported most of our cast-iron pipe from Scotland. But it was not many years before our manufacturers departed from these patterns and devised, first, a modified wedge valve, one with the wedge principle but double disks, forced to their seats by inside wedge action.

About the first of this type was the Peet Valve (Fig. 1), not now manufactured. This was a taper seat valve, of the wedge principle. The valve was fitted with a pear-shaped wedge, the large end downward with an extending spindle which engaged with a projection cast in the body between the seats, so that as the valve closed the spindle came in contact with the projection in the case, and the further travel of the disks caused the wedge to force them to their seats. Some of the double-disk valves in use to-day are developments of this type.

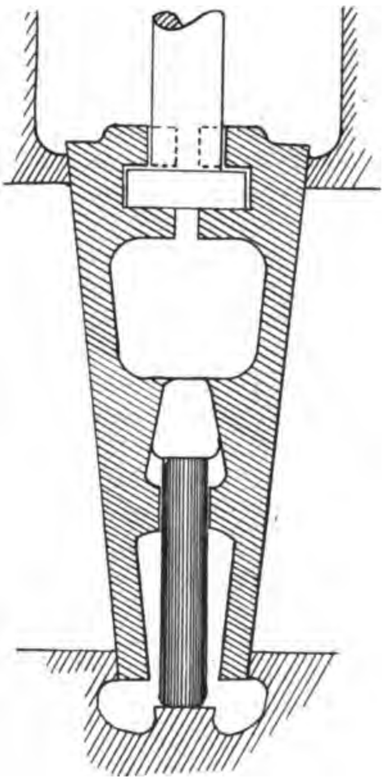


FIG. 1.
PEET VALVE.

In operating a parallel disk valve, the instant the pressure on the disks exerted by the wedge nuts is released, they are perfectly free to rise from their seats; there is absolutely no sliding or rubbing motion between the seat rings and the disk rings, the parts of all valves that make them tight when in good condition, and cause leaks when worn or injured. In closing the valves the disks are free until in their place opposite the seat ring, when the only motion is an outward pressure against the seats, without any sliding or rubbing to cause wear on the gate rings. The only possible grinding or rubbing of seats is when the pressure is all on one side of the valve. A little care in the operation of valves soon relieves this as a very small opening will quickly equalize the pressure; with large size valves this is accomplished by the by-pass, saving wear on the main valve.

Various devices have been contrived by valve manufacturers

for expanding the disks to their seats, each claiming superiority in this particular. But we who use double-disk valves believe that while the disks are free to adjust themselves to their seats there should be as little lost motion as possible between the disks and seats, so that when operated the disks are in practical contact with the seats, thus shearing off any accumulation of rust, sediment, or foreign substance of any kind, and insuring perfect contact when the valve is closed. In all of the better makes of valves both the seats and contact part of the disks are of noncorrodible metal, so that there is no rusting of the contact parts to affect the tightness of the valves. Both types are wedge valves, depending on wedge action for tightness; the wedge action of the double-disk type being accomplished by the wedge nuts, which take all of the rubbing or grinding wear, while in the solid wedge type this wear comes on the gate or disk and seat rings. Wear on the wedge nuts, which are made of hard material, will be less than on the softer metal of the packing rings, and will not affect the water-tightness of the valve. This wear is also easier to repair than that on the packing rings, especially the seat rings. Wear on the seat rings of the solid-wedge type of valve seems to the writer to be sure, in time, to cause leaky valves. Of course the clearance at the bottom of gate chamber allows for wear, permitting the gate to go down until it is tight; but such wear would have to be absolutely uniform and equal on both the wedge and seat to leave a tight valve.

As to the mechanical design of the solid-wedge type; is there not difficulty in machining both bodies and plugs to a standard? Undoubtedly there are special machines for this purpose, and possibly the difficulty has been overcome; but has it been overcome to the extent of making all parts interchangeable? Is it not necessary still to fit each plug to its own body?

Some difficulties in this respect seem to have been encountered, as various devices have been used to obviate them, such as casting the bodies in two sections and, after machining, bolting them together with the plug in place, and using a lead gasket between the flanges. The writer does not know how satisfactory this proved, but can see a possibility of trouble owing to the distortion of the lead gasket. Another device tried was using a solid body and

casting a soft metal seat. But it would seem that the soft seat would have a short usefulness.

After all, is not the wedge-shaped double disk, or even the parallel disk type, a modification of the wedge intended to overcome the difficulties met with and defects found in the solid-wedge type, starting with the Peet valve and gradually developing into the modern double-disk type of valve in general use to-day?

An objection to the solid-wedge type is the fact that the gates always seat in the same place, and when foreign substance is trapped between the gate and the seats the seats would become so damaged that the gate would leak. In parallel seated or double-disk valves the gates do not seat twice in exactly the same place; in some makes the disks completely revolve, bringing always a different part to the seat. Therefore, should solid matter be caught between the gate and the seats, the marring will not cause serious damage, as the dent in the disk will not come opposite the corresponding one in the seat, and the compensating feature of the parallel seat valve, permitting a certain amount of give, takes care of some irregularities in the contact parts.

Then the difficulty in repairing a bevel-seated valve, the replacing a marred or defective ring, is of quite serious moment. In fact, it is very doubtful whether a solid-wedge valve could be reseated without cutting it out of the pipe, on account of it being almost impossible to get the bevel the correct angle to fit the solid-wedge gate. In other words, it would be necessary to cut a valve out of the pipe and return it to the manufacturers. Whereas, in the case of a parallel seated valve, it is not at all difficult to replace a seat ring when the valve is in the pipe, and should it be necessary to remove it from the pipe, it could be refaced at any general machine shop in the town or city in which the valve is located.

Now, it will be urged that valves are seldom used, and that the wear on the working parts would be very slow in any type of valve. This in the main is true, but does not seem to be a good argument in favor of adopting a valve that will not stand the wear of frequent use, all other things being equal.

Mr. Finneran speaks of the liability of the double-disk type of valve vibrating in operation, opening or closing, because of

the looseness of the disks when unseated. As hereinbefore mentioned, the double-disk and parallel seat valves are made with the least possible lost motion, consequently the looseness is not sufficient to cause serious vibration. The writer, after more than forty years' experience with this type of valve, cannot remember any such action of sufficient violence to be even noticeable. Is it not a fact that the solid wedges are loose, having a considerable play in the grooves, until near their final seat? Surely, if they were a close fit there would be friction between guides and wedge during the entire operation of opening or closing.

The continued improvement in the double-disk type has been so rapid, and the service given by it so satisfactory, that the use of the solid wedge is rarely considered except in old installations, where, probably, the newer type has not been tried.

The writer finds no record of a manufacturer of parallel seated or double-disk valves changing over to the making of the solid-wedge type, while there are a number of makers of solid-wedge valves now making double-disk valves as well as their original type.

One might infer from Mr. Finneran's paper that the double-disk type of valve was rather new, when he says "a number of manufacturers have abandoned the old solid-wedge type plug and taken up with the many kinds of loose double disks." It is true that most of the manufacturers who commenced with the solid-wedge type are now making the double-disk valves also; but there are several manufacturers who have never made anything but double-disk or parallel seat valves, and some of them have been in business over half a century.

DISCUSSION.

Mr. Finneran. I understood Mr. Diven to say in his paper that about the only time that a double-disk valve is exposed to frictional resistance is while opening or raising. I find in my experience that considerable frictional resistance is encountered in closing or going down. When closing a valve, because of a break in the main, with a flow of water out through the opening, an unbalanced pressure is encountered that tends to force the

wedge with great stress towards the opposite seat. As the wedge descends into the water-way with an increasing area exposed to pressure, a correspondingly increased frictional resistance has to be overcome. This friction or drag is on the guides until the wedge has almost reached the bottom, when it is transferred to the seat opposite the direction of pressure.

Mr. Diven expressed some doubt as to the practicability of having the angle of taper correspond in the wedge and seats. That is easily accomplished in manufacture by having a special angle or taper plate fixed to the lathe so that plugs and seats will have their faces cut at exactly the same taper.

Then, again, he speaks about the rubbing of the rings; I presume he refers to abrasion caused by foreign substances in the seats. Generally speaking, valves in distribution systems are not operated very often — an average of once a month is high. I know of valves that, except as a matter of maintenance or test, are not operated once a year. So I do not apprehend much danger from that source. Furthermore, the solid wedge, because of its taper, does not come in contact with the seats except during the end of its descent or the beginning of its ascent.

In considering the relative merits of solid wedge and loose double-disk types of valves, I am impressed with the proposition that there is practically but one seat to a valve in operation. By an unbalanced pressure and a small amount of play in the guides the wedge is forced tightly against that one seat. What is the use of an additional seating necessitating the extra force required to overcome the unbalanced pressure and to expand both disks to a double seating?

Mr. Diven. Mr. Finneran goes back to the very proposition that the speaker brought out, and that is, the fact that valves are infrequently used is no reason for adopting a valve that will not stand frequent use. Of course in a distribution system many valves, except for their annual or semi-annual or possibly more frequent tests, are not used from year's end to year's end. Possibly some of them are never used in actual service. But in filter plants and pumping stations valves are used with great frequency. The speaker has a 30-in. valve in use which is used from once to twice a day changing water from a storage reservoir first into

the low service and then into the middle service. That is a double-seat type of valve, and has been in use since 1905 without any repairs whatever. The speaker's experience with trouble with valves is, of course, the same as everybody else's, — that the most trouble is in the stem. But the great argument in favor of the double-disk valve is that the wear and strain of use comes on the rugged wedge rather than on the delicate seat of the valve or the seat-ring, which, to the speaker's mind, is really the most delicate part of the valve, the part that we depend on for water-tightness. Of course we all know how troublesome leaky valves are. We have to go back and take in another section, and people that have to have short notice complain; in fact, the shutting off of the water is a disagreeable thing for the water-works manager anyhow, and the less of it we can do, the better.

MR. WESTON E. FULLER.* Probably the most severe use that valves in filtration plants get is on the wash-water lines of mechanical filters. The speaker has recently had occasion to renew some of the seats on wash-water valves of a mechanical filter which had become badly worn. The wearing in this case was probably increased materially because the valves were used in a partially throttled position, the rush of water through underneath the disks wearing the valve seats very rapidly. The question comes up to-day: What would have happened if these valves were of the solid-wedge type? The ones I am speaking of were double-disk valves. Probably the cost of renewing would have been much greater with the solid-wedge type. I would like to hear from others who have had experience with filters that have been in operation ten or twelve years.

MR. FINNERAN. One of the greatest troubles with valves is due to the accumulation of rust or other solid material in the recess between both seats of the valve at the bottom. It is quite a problem. If some device could be invented or produced that would eliminate or reduce that accumulation, it would be of great value and much appreciated.

MR. DIVEN. Isn't that accomplished in a large measure in our every-day practice by merely closing a valve, opening hydrants or flush-gates on the downstream side, and getting a strong current

* Civil Engineer, New York.

of water under the valve, working down into this chamber, carrying away any collection of sediment.

Mr. Finneran. In a city where there are about 15 000 valves, it would necessitate quite a little labor to go around every short period and wash out under the wedges of each valve.

Mr. Diven. We do that only while using the valves. It might be a very good thing to keep them clean, but the speaker has had very little trouble in cleaning out any accumulation of mud with a good and sufficient velocity of water. Perhaps if the entire chamber was lined with bronze the difficulties would be less, but that would make the valves more expensive, and seems unnecessary.

Mr. A. O. Doane.* I have had considerable experience with valves since the beginning of the Metropolitan Water Works, and have had many talks with the late Mr. Brackett on the merits of the double-disk and the wedge valve. He was always very much in favor of the single-wedge valve, on very much the same grounds that Mr. Finneran has taken, and perhaps from the same line of experience, as he was with the Boston Water Works for years. He believed in the simplicity of the wedge type against the complications, or alleged complications, of the double-disk type. My personal experience in the actual operation of valves has been somewhat limited, but I have had considerable experience in following the manufacture, and I believe there are some good points in both systems. That is to say, it is hardly fair to make any general statements condemning either one type or the other. I believe that the solid-wedge type is considerably simpler and that the wedges, as they are generally made, are stronger mechanically than the double-disk type.

With regard to the points that have been brought up, about the wearing of the valves by opening, it seems to me that the valves in both types seat very much the same. That is, when the gate is shut and you open it with unequal pressure on the two sides, in both types the disks or wedges drag over the seats at first. In the wedge type, as we make them, with a very little clearance between the guides in the body and guides in the plug, and a bronze lining in both the wedge and body, then the valve almost imme-

* Division Engineer, Metropolitan Water Works.

diately leaves its seat, being drawn away on account of the small clearance between the guide in the body and the guide in the wedge. So there is comparatively little dragging action. But most commercial valves where the guides are not lined have a large clearance there, so that the wedge type does drag over the seat for a considerable distance when they are opened. Now I think that same thing is true of almost any type of double-disk valve I have seen, as, when either closing or opening under an unequal pressure, the disk does scrape or drag across the seat.

In regard to the abrasion of the seats by gravel, sand, or other grit, it has been my experience in testing valves that a very small particle of grit will ruin the tightness of the valve. In regard to the point being made of the valve seating in a different place in the double-disk type, it does not seem to me that that would ever have much influence, for the action of a particle of grit is to make a score across both seats, probably with slightly raised edges. Now, it does not seem very material whether a disk changes position or not. The scratch is on the seat, and the edges of that scratch are going to keep the disk away from the seat and cause a leak, whether the valve seats in some other place or not.

Concerning the mechanical features of the valves; on the Metropolitan Water Works all valves on the pipe lines are of the wedge type, but there are a few valves of the double-disk type in the pumping stations. The experience we have had with these valves has seemed to me to be ample confirmation of Mr. Brackett's views about the complication of this type, because we have had considerable trouble with these valves, on account of parts giving out. In some cases when we wanted to start up a pumping engine we would find that while the valve is apparently open, only one of the disks was open and the other was down. As that occurred two or three times in a period of ten years it rather confirmed us that our views were right on the wedge principle. We were rather glad we did not have several thousand of them. I know that many of the towns and cities using double-disk valves apparently have no trouble. Perhaps our trouble was rather exceptional in that these valves were operated often.

In regard to operating valves frequently; we had one 36-in. valve of the solid-wedge type with bronze-lined guides and bronze

seats and faces, that was operated from at least two to four times a day for a period of nine years to regulate pressure. The valve was not tight as it was usually kept a few inches open, and the water had worn the seats considerably, yet after a period of nine years all that had to be replaced was the stem and the stem nut, because the threads were worn out. It simply meant a new stem and stem-nut, at a comparatively small expense, to put the valve in service again.

With regard to the manufacture of the valves, the question has been raised about their interchangeability. There seems to be no difficulty in the present shop practice in any single manufacturer making valves that are absolutely interchangeable. The practice of the large manufacturers is to machine the seats and faces of the valves on a boring-mill. The flanges or faces of the bells are machined first and are then placed on taper-plates having exactly the same angle that is used in both the body of the valve and the wedge. The wedges are machined to gages which limit the thickness so that there is no trouble whatever in taking a wedge out of any gate and putting it into another gate, or reversing the wedge in the same gate and having it tight.

I will agree that when it comes to repairing the seats, theoretically anyhow, the double-disk type is easier to repair, — as worn seats and disks may sometimes be renewed without removing the gate from the pipe line, though one of the prominent manufacturers of double-disk gates has told me that it generally comes to a case of sending the valve back to them, after all, if it is a large valve, and particularly a valve that has been in use a long time.

MR. DIVEN. The speaker was very much interested in what Mr. Doane said about one disk dropping down and leaving the other up. That, in any type of double-disk valve the speaker has examined, would be an impossibility. If anything happened to let one disk down, both would go.

He also spoke about the damage from scoring and seating in the same place making no difference. The metal of the ring and the seat are, as far as the speaker knows, the same, and would score equally. With the valve seating always in the same place, those two scored portions would come opposite each other, and there

would be double the leakage that there would with a revolving disk not seating in the same place.

As to the interchangeability of parts, while they may have the machinery in the shop perfected, in use the wear would be on the seat as well as on the plug, and any standard plug put in would not fit the worn seat. It seems as though the plug would have to be ground to fit that particular seat to make up for the wear or else a new seat put in with the plug.

A matter that was brought to the speaker's attention was a case in point, where the wedging sprung the body of the valve a considerable amount. This did not cause a leak, it being the double-disk type of valve, the flexibility of the valve made up for this. But with a solid-wedge valve this would be just as apt to occur, and there would be no take-up to it. Of course we will all concede that the body of the valve should not spring. It should be made so that it will not.

MR. DOANE. With regard to the scratches coming opposite; it is undoubtedly the fact that if we could imagine that there is a score of perhaps one one-hundredth of an inch across the seat of the disk, and the valve seats right to a mathematical line, — then those two scores would come opposite. But I think in the ordinary valve it would be a thousand chances against one that that wedge could ever be put down in position so that those two scores would come opposite each other again.

Concerning the point that was raised about a valve body springing, that the double-disk valve would take care of it better: That may very likely be so if the valve springs considerably more than any well-designed valve should, but with our wedge type of valve, even with the small clearance that we allow, we have never found any difficulty about the wedge having clearance enough to deflect the very small distance required to make the seat tight. There is a type of solid-wedge valve made that has a central portion cast solid between the two disks and then the spring of the disks under the water pressure takes care of any spring of the body. That has worked out quite successfully and depends entirely on the elasticity of the cast iron. There are no loose parts in the wedge at all.

MR. W. C. HAWLEY.* We use the double-disk type of valves

* Chief Engineer, Pennsylvania Water Company, Wilkinsburg, Pa.

at our filter plant. They have been in service now a little over five years and we have had no trouble with them. The first water plant I had anything to do with was finished twenty-nine years ago. We used the double-disk valves there and those valves are still in service, and so far as I know have given no trouble. In our own plant we are using the double-disk valves. We have used one type now for nearly thirty years and we have no trouble with the scoring of the disks or the seats. The weak point is the stem. I think that is where we have most trouble with our valves. I have had no experience with the solid wedge valve except two 8-in. valves that were put on a large pumping engine and operated on a by-pass under a pressure of about 250 or 260 lbs. Those valves failed inside of a year. We replaced them with the double-disk type and they have been in constant use ever since, about ten years, and we have had no trouble with them at all.

I think we ought not to lose sight of the fact that there are two distinct types of double-disk valves, one in which the disks come down opposite the seats and are then wedged apart against the seats, and the other where the disks wedge into place against the seats as they are forced down. I do not purchase valves of the latter type, as I believe that the former is the better design. My experience has been entirely with that type of valve.

MR. JOHN H. GREGORY.* I might mention an experience with solid-wedge valves which came under my observation a few years ago. Some eight or ten 36-in. valves designed for about 100 lbs. service pressure were tested under 125 or 130 lbs. pressure. The specifications under which the valves were purchased provided that the manufacturer should submit his own designs, and the valves were made in accordance with these designs. The valves were tested with a blank flange first on one end and then on the other end, and finally, with blank flanges on both ends. The valves were supposed to have been made heavy enough to stand the test pressure, but as a matter of fact the bodies were not strong enough and the valves leaked when tested in the shop. The manufacturer replaced the valves with heavier ones, making the bodies very much heavier so as to be stiff enough not to distort under pressure. With a solid-wedge valve the body should either be

* Of Hering and Gregory, New York.

stiff enough not to distort appreciably under pressure, or else the wedge gate should be designed to distort so as to follow the distortion of the body.

In the Columbus plant the valves are of the solid-wedge type, and, as far as I know, up to the present time no trouble has been experienced with them. The plant was started in operation about seven years ago, and the last time that I visited the plant I did not hear that any repairs had been made to the valves.

MR. FRANK C. KIMBALL.* In regard to the action or the working of gates in filter plants, we had a mechanical filtration plant in Knoxville, Tenn., that was installed in 1895, where certain gates had to be operated for washing, from perhaps a maximum of four times a day to a minimum of once every two days. The last I had to do with that plant was in 1909, — about fourteen years after it was constructed, — and without stating definitely, to the best of my knowledge none of those gates had been replaced at that time, and with the exception of two or three stems, no repairs had been made upon them. These were of the double-disk and wedge pattern. What has happened since 1909 to these valves, I cannot state.

MR. WESTON E. FULLER. The case I mentioned where the seats on the wash-water valves had to be renewed was with the use of water for washing purposes under a pressure of 70 lb., so that the conditions were quite different from those in a filter plant where low-pressure water is used for washing. Under the high pressure the valves were throttled down so much that a very high velocity resulted under the disks, with a consequent tendency for wear. I may say that these valves were used for some twelve years under these rather unusual conditions before the seats were renewed.

MR. ROBERT J. THOMAS.† Every superintendent of water works has had a lot of trouble with all kinds of valves. It is not a question of a satisfactory gate. It is rather a question which type of gate will give the least trouble. For that reason I regret that the manufacturers of valves are not present so that they might learn something about how the valves work in practice. They have not had the experience in operating valves that water-works

* General Manager Commonwealth Water and Light Company, Summit, N. J.
† Superintendent of Water Works, Lowell, Mass.

superintendents have, in making extensions, alterations, etc. It is very seldom that you can find a tight valve. If you have five or six valves off, there is sure to be one of them leaking. We all know what a lot of trouble that means. If the manufacturers knew all the trouble that leaky valves cause the water-works superintendents and water takers, they would, I am sure, try to do something better for us. Sometimes, owing to defective valves, it is necessary to shut off a greater area than should be necessary, forcing the conclusion that you cannot have any too many valves. The old idea that a valve on every line of street was enough, you will find is not right, when you go to use that valve, especially if it has been in use probably thirty-five to forty years, for it will not close down tight. Therefore you have to go to another valve, another block away. I have told our men in putting in valves lately to put in about twice as many as were formerly thought necessary so that if one gave out we would have another one near by to fall back upon. We are putting valves now on all of the hydrant branches, and the underwriters require it because of the fact that the valves are not to be depended upon. In pumping stations, where valves are operated often, it is very easy to determine which is the best working valve. Take a valve that has been closed for several years, on a blow-off from a force main. When you come to open it you will find, if it is a solid-wedge type of valve, that it is impossible to operate. I have found it so. You may break the stem, but it takes quite a while to get a new one. My experience has been that all valves give more or less trouble. But we have had to replace by far more valves of the solid-wedge type than we did of the double-disk. I notice at different places throughout the country where they are putting in filter plants that most of the valves, the big valves, are of the double-disk pattern. I suppose they favored that pattern only after investigation and study being convinced it was the best. It may be different in Boston, where they make their own valves. Maybe they make the solid-wedge type of valve better than manufacturers do. I do not know any other explanation why that type of valve works more satisfactorily there than it does in other places, unless it is because they make a better valve than the manufacturers do.

MR. W. C. TANNATT, JR.* In Easthampton we have just about an equal amount of double-wedge valves and solid-wedge valves, and I find that the biggest trouble with ours is the sediment accumulating underneath the seat will not allow the valve to seat properly. I have also found that in working the valve up and down it is easier to free a solid-wedge valve than it is a double-wedge valve. In replacing valves we have made it a rule now to discard the double-wedge valves in favor of the solid wedge.

MR. DANIEL A. MCCRUDDEN.† I agree with Mr. Thomas that the wedge type of valve is really much harder to open after it has been left closed for ten or fifteen years, as quite often happens, and there is much more trouble with it than with the other type of valve. There are quite a few valves in a system that have to remain closed on account of a difference in pressure. They are very rarely operated except in case of trouble on one system, when it is desirable to take water from the other. In such a connection, a wedge type of valve is far superior to the other type.

We have, I dare say, about 28 000 wedge-type valves, and quite often the closed valves cause trouble. But as far as the sediment at the bottom is concerned, there is only one way to remedy it, and that is the precaution we have taken of operating the big valves every three months, and all valves on the system at least part way at least once a year. That will remedy the trouble of sediment in the bottom. Of course it is a big job to operate all of the valves in the town once a year, and we have not gotten it yet. We are trying to.

MR. FRANK L. FULLER. The Wellesley works were built about thirty years ago, and the large majority of the valves put in were the double-disk type, and I have never heard any complaint in regard to them. From time to time solid-wedge valves have been used, and I have no further knowledge about them. In other works with which I have been connected it has been sometimes one type and sometimes the other, and as a general thing I think they have worked satisfactorily. Much trouble comes from the accumulation of sand and grit under the gates when they are opened and shut in flushing the pipe system, when the works are

* Easthampton, Mass.
† Purveyor, Bureau of Water, Philadelphia.

new, and from grit and gravel being caught between the valve and seat. In this way they become cut and scratched and in consequence leak. It is very necessary, I think, that the pipes should be thoroughly flushed and all the grit in the valves removed. The valves should be put in closed and as the water is gradually let on from one line of pipe to another these valves should be opened, as necessary, and the pipes thoroughly flushed by opening hydrants. The water should be drawn out, as long as there is any indication of grit and gravel, and a good deal of water passed through the pipes, to be sure that they are thoroughly cleaned. If that is done, either type of valve will be satisfactory.

MR. PATRICK GEAR.* For sixteen years before I became superintendent in Holyoke I had been out fixing the gates when they were broken, making the spindles for them, taking them apart, and putting the spindles in, and finding fault with the maker of the gates because he did not make them right. I still keep finding fault with him because he has not improved them any.

Now what trouble did we find with the old gate that we got in the system forty years ago? We have the same trouble to-day. One speaker says if the gates are operated once a year or oftener we will get away from the sediment in the bottom, but if there are 40 000 gates there, the people would say there is an awful waste of money, operating those gates every day and stirring up and making the water dirty for the laundrymen and the washwomen. I say if the manufacturer makes the gate properly we won't have any trouble in shutting the gate down and making it tight. I sympathize with the man who is around trying to sell the gate, because when we find fault with him and tell him it is no good because it hasn't this, that, or the other, and he goes back to the manufacturer and says, "So-and-so of such a town told me it ought to be done so," they say, "Why, he doesn't know what he is talking about." That is what they will tell him. If the gate is made with a good space at the bottom of it, a couple of inches — I don't care what size the gate is — perhaps two or three inches in the bottom — and have the brass ring stick out a half of an inch so that it would not be right up against the cast iron, there would not be any trouble with sediment. I have taken gates apart that

* Superintendent of Water Works, Holyoke, Mass.

have been in for forty years, and when I have taken them out, taken out the rust, and put in a new spindle, they were as good as ever. If they were made properly at first they would be all right. Now the spindle in a 6-in. gate is $1\frac{1}{4}$-in. in diameter, but at the bottom of the thread it is about $\frac{7}{8}$-in. Did you ever know of a spindle to break around the stuffing-box? I never did. They always break at the bottom, between the nut and the shoulder. Just as soon as they put the strength where it belongs we will have less trouble, but when they are putting the strength in the spindle where it never is needed, it is no good to us. They are talking about the double valve and single one. The men who sell the double one will tell you it is better. One gentleman said, a little while ago, that one side of the double disk might lift up before the other. There is one gentleman selling that type and he says it is good because it will give a lift of one side before the other. There may be something to it. But I know we have got both of them and we have got trouble with them. And it is all up to the manufacturer. Now, if the gentlemen from Boston made the gates, they should be perfectly satisfactory. I know if I were making them I would guarantee I would never have trouble.

Mr. Daniel A. McCrudden. I believe that operating valves is the biggest advantage you can have and the best way to spend money. A gang of three men in one district has operated over 6 000 valves in three months. The first time they operated those valves it took six months. The last time it took just three months, showing how far superior our valves are in that district than they were a little over a year ago, when we can do it in half the time it did take us previously. We have in that district about two hundred 36- to 48-in. valves and we can do that work in something like four days. When I was in that district two years ago, to operate, repair our big valves, it took me something like three months to get around those one hundred fifty valves and put them in good condition. But they are doing it now in four days out of every three months, with a gang of three men, where I had to have at times eight and ten men to move the valves. So I think it is well paid work.

Mr. Gear. I want the spindle and stuffing box improved, and then you won't have trouble in operating the gates, — if it is idle

ten years. I found a gate once when it took three or four men to open it. I dug it up and found there was a cast-iron stuffing box, and a cast-iron gland in that gate. They were stuck so that you couldn't move it. When I took them apart and cleaned them, the gate was all right. Now, if valves could be made with a brass stuffing box, brass nuts and bolts, brass gland, and a brass lining on the top of the gate where the shoulder of the spindle rests, you will never find a gate stuck in forty years. The trouble comes there. You won't find trouble operating a gate made in this way, and you won't have any leaks either.

Mr. A. E. Martin. If the purchasing agents of the different cities would pay a little more attention to the quality of the gates they buy instead of the price, our manufacturers would build the gates that are needed. The superintendent knows what he wants, but when he goes up against a purchasing agent who, bound to make good in his department, insists on giving his order to the lowest bidder, he does not always get the best. The manufacturer has got to build for the purchasing agent and not for the superintendent.

Mr. Finneran (*by letter*). I have recently examined a number of valves which have had varying lengths of service, some with fifty years or more, and I noticed little or no injury to the rings or plugs due to abrasion. I found in some of the old valves that the rings were displaced, as the iron backing had rusted away, leaving them without support. Some double-disk valves showed much wear in the trunnions, particularly one that had been near a locomotive standpipe. The plug can be removed without difficulty from any type of valve without disconnecting it from the pipe line, but the seat ring cannot be. It seems important, therefore, to give more attention to the method of securing the seat rings. A variety of methods are used; in our practice the rings are driven into slots and pinned.

While I think that both types of valves depend upon good materials and workmanship to give satisfactory service, I believe that the simplicity of the solid-wedge type, with its few moving parts, commends itself for long periods of general service.

WIRE FENCES AND CONCRETE POSTS.

BY RALPH N. WHEELER, DEPARTMENT ENGINEER OF THE BOARD OF WATER SUPPLY, NEW YORK.

[*Read September 8, 1915.*]

Many miles of wire fencing on concrete posts have been erected during the last three years to define lines of property taken for the Catskill aqueduct and reservoirs, and to mark rights-of-way and road crossings over city property, all the work being done by contract. The purpose of this paper is to call attention to some of the points to be observed in order to get the best results in constructing fences of this type.

Several cross-sections were used for posts, all reinforced, the posts generally tapering from the bottom toward the top. For the so-called line post the T-section, reinforced with three No. 5 gage wire rods, was most generally used, but on some parts of the work a D-section reinforced by four similar wires was preferred. D-posts being built under an existing contract have four ¼-in. twisted rods. The line posts were generally 7 ft. 3 in. long, and made to set 2.5 to 3 ft. in earth and not less than 1.75 ft. in rock. For straining, gate and latch posts, the square cross-section was used, reinforced with four ¼-in. or ½-in. square twisted rods, depending on the length of the post. No ornamental tops were used, the only attempt at ornamentation being to provide pyramid tops for hinge and latch posts.

All posts were cast in thin sheet metal forms in horizontal position. The D or T sections were assembled by the battery or table method. The battery method employs a small steel car with hinged ends, so designed as to permit the placing and filling of five layers of six molds each; the table method makes use of a skeleton table on which the molds are placed. Both methods provide for tightly closing the ends of the molds. Preference is expressed for the table method, as the faces of posts are exposed for troweling or rubbing at the proper time. Slightly more floor

area is, however, required. Objections to the battery method are the drip from the upper layers, which tends to pit the faces of posts below, and the impracticability of troweling or rubbing the faces. Joggling, essential for properly expelling the air, is accomplished by shaking the skeleton table or moving the battery car back and forward along its track.

To secure good posts with either method the following points must be observed:

1. Molds should be coated with a thin film of oil.

2. Concrete aggregates should be of two sizes, well graded; the fine up to $\frac{1}{4}$ in., and the coarse from $\frac{1}{4}$ to $\frac{1}{2}$ in. for the smaller sections of post and $\frac{1}{4}$ to $\frac{3}{4}$ in. for the larger.

3. The mixture must be very accurately proportioned, analyses being desirable to determine the exact proportions. Generally about one part of cement to three parts by volume of aggregates gave the best results.

4. The concrete must be thoroughly mixed and of wet consistency.

5. The ends of molds must be sealed tightly with clay, plaster of Paris, or cement, to insure good tops.

6. The air must be expelled by joggling and running a trowel back and forth through the mixture and along the sides of the mold while placing.

7. The reinforcement must be placed in correct position. This can be accomplished without a spacing device after a workman becomes skilled.

8. The reinforcing metal, particularly round wires, should be thoroughly rusted or nicked to give a proper bond. Bending the ends of these wires back 180 degrees gave good results. As received from the mill, these wires were greasy from the drawing process, and it was found necessary to hasten rusting by the use of a weak acid afterward neutralized. Posts tested to failure showed that unrusted straight wires would pull through, whereas properly rusted ones, or those with ends bent, would break. It has been suggested that running the wire through a barbing machine such as is used in the manufacture of barbed wire nails would deform it sufficiently to give a good bond. This would add not over one-half cent per pound to the cost.

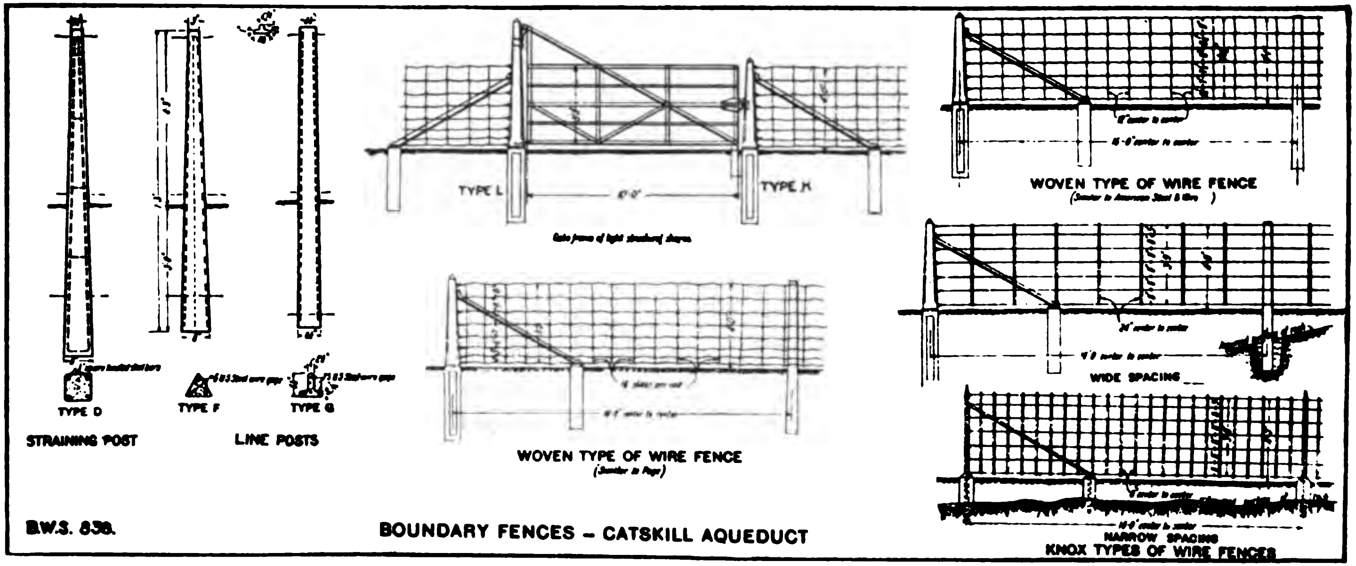

TYPE D
STRAINING POST
TYPE F
TYPE G
LINE POSTS
TYPE L
TYPE K
WOVEN TYPE OF WIRE FENCE
WOVEN TYPE OF WIRE FENCE
WIDE SPACING
NARROW SPACING
KNOX TYPES OF WIRE FENCES
B.W.S. 838.
BOUNDARY FENCES – CATSKILL AQUEDUCT

Fig. 1.

9. Posts must be properly cured. They can be removed from the molds in thirty-six hours, and may then be stood in a vertical position and water sprayed over them from suitably arranged piping, or preferably they may be spaced in a horizontal position and covered with sand or sawdust kept wet. Curing should cover at least two weeks, and better four.

10. The rounding of edges of the exposed face can be accomplished in the form, but better by rubbing with a carborundum brick after erection and before the wire is stretched. If fencing is attached by wrapping wires, rough edges assist in holding the wires.

The T-section posts weigh 90 to 100 lb. each and require very careful handling. They were transported from the casting yard to the work in spring wagons or trucks, generally about forty posts to the load. Tests showed that the strength of the T-post was greatly increased by substituting three ¼-in. twisted rods for the three No. 5 gage wires, the weight of the reinforcing metal being practically doubled by the change.

Posts were set not less than 30 in. in the ground, and efforts were made to secure a pleasing profile of the tops. It was found very desirable to place stones in the holes around the bottoms of posts and to thoroughly tamp the refill. In swampy ground and where the fence line was curved, posts were generally concreted in, as otherwise the strain of the fencing would throw them out of line. It was found desirable not to set posts in filled ground, as on right-of-way banks, until the filling had stood through at least one winter.

Straining posts were placed at irregular intervals to suit the topography and alignment, but never exceeding 600 ft. apart. The average interval was somewhat less than 300 ft. Early experience proved that such posts should be concreted in. Two permanent angle iron braces were generally used on straining posts, but in case the angle in the line made this impracticable, a straining post was set at the angle point and another 16 ft. away, each provided with a single brace. The proper location of straining posts is of great importance if a tight, good-looking fence is desired. Therefore special study of this detail is necessary. Early in the work concrete brace bases were cast and set in position to support the lower end of the angle iron brace. Better

results were secured later by digging a hole and filling same with concrete, in which the lower end of the brace was set. Gate and latch posts were generally set in concrete, this method proving more effective in preserving alignment. All property line posts were set with the face on the proper line; in other words, the posts are entirely on city property.

Two general types of fencing were used, namely, factory and field woven, the use of the former being more general. Both types were No. 7 gage throughout and had seven horizontal strands, all heavily galvanized. The field-woven fencing was of the Knox type, with pickets spaced either 8 in. or 24 in. This type was used in more conspicuous locations, or over very irregular ground. The factory-woven fencing, made by the American Steel & Wire Co., was delivered in 20-rod rolls, and weighed about 1.1 lb. per foot. The weight of Knox fencing with 24-in. spacing of pickets is about the same. For erecting factory-woven fence, stretching, wrapping, cutting, and crimping tools were required. For erecting the Knox type, a pair of light blocks was required for controlling the strain in each horizontal wire, also a special tool for fastening the pickets to these wires. Many methods of fastening fencing to posts were considered; the following one was finally adopted and successfully used. At end, corner, and straining posts the horizontal line wires were carried around the posts and wrapped on themselves, interfering verticals being cut out and the fencing kept under strain while this wrapping was being done. At line posts short wrapping wires, first of No. 12 and later of No. 9 gage, were used. These wires were delivered in bundles, each wire straight and long enough to make two wraps. They were cut into proper lengths, one cut giving the pieces for wrapping the top and bottom horizontal wires, another the second and fifth, etc., thus avoiding any waste. Two men generally worked together attaching these wires. The operation was performed as follows: A short bend was first made near one end, giving sufficient material for wrapping four times around the horizontal wire; it was then placed in position snugly against the side of the post and wrapped. The loose end was then carried snugly around the post and wrapped four times around the line wire on the other side. Care must be taken to keep the wrap in the horizontal plane of the line wire and to have it tight and snug

FIG. 1.
FENCE GATE WITH CHAIN FOR LOCKING; DETAILS OF BRACING THE GATE; AND MANWAY POST.

FIG. 2.
STANDARD CORNER CONSTRUCTION WITH SQUARE CONCRETE POST BRACED IN TWO DIRECTIONS BY STEEL ANGLE-IRON BRACES.

against the post. Done in this way, the fencing cannot be lifted up, and the batter of the post prevents sagging. This method of wrapping is preferred because it does away with special attachment pieces or holes in the posts, permits the stringing of wire any distance above the ground or below the top of post, and is economical. Wrapping tools can be bought for a few cents each from fencing manufacturers, or can be made by a handy blacksmith. Fencing was erected during practically every month of the year. Probably better results were secured from the warm weather work, although this undoubtedly caused more of a strain on the posts due to contraction in the colder months.

Galvanized angle irons 2 in. by 2 in. by ¼ in. by 7 ft., or 2½ in. by 2½ in. by ¼ in. by 9 ft., were used for braces; these were bent to fit the side of the post at one end and the concrete anchorage at the other, with holes at each end for attachment. The better way is to bend the upper ends of these braces at a sharp radius with a slotted hole where bolted to the posts to permit adjustment on sloping ground. The bottom ends can be simply bent down and concreted into the brace block. However, even this type of brace cannot be conveniently cut to length in the field, and those contemplating erection of fences should consider braces of 1½ in. galvanized pipe. These can easily be made up in the field to special lengths, and the use of couplings prevents wasting short pieces. One end should be flattened down for four or five inches, bent to the desired shape, and drilled for the bolt connection. The other end is bent slightly and concreted into the anchorage or flattened and secured to a bolt in the anchorage. It is understood that reinforced concrete braces instead of angle irons have been used in the outskirts of Brooklyn for the wire fencing along the Sea Beach route of the new subway system put in operation this summer.

Gates generally 10 ft. long, made of angles and flats, were used freely in the line and right-of-way fences. A somewhat wider gate opening seems desirable. The top support is made adjustable, and all hinge supports, top supports, latch plates, and bolts are heavily galvanized. This is desirable when the difficulty of securing a good paint for exposed metal work is considered. Gates are locked by inserting the tongue of a small brass padlock through a hole drilled in the latch.

Experience to date has indicated no likelihood of trouble with the posts, although adjustments of gates and their supporting posts have been necessary, particularly on field rights-of-way. Early in the work the posts offered tempting targets to hunters, but it is believed the novelty has worn off. Frequently, too, some country Hercules would try the strength of the posts after erection and before wires were strung, by pulling back and forth, generally with disaster to the post. Once the wire is strung this danger is removed. The importance of securing dense, smooth tops is obvious, as disintegration by frost action is thereby reduced or eliminated.

It appears to the writer undesirable to attach fencing to either the hinge or latch post of a gate, as sooner or later the strain throws the gate out of line and adjustments are necessary. It is better to set extra posts, one of which should be spaced for a manway. Manway openings should not be too wide, particularly in regions where live stock is pastured. It is better to make them so that a man must turn sideways and then contract as much as possible to get through; in other words, the opening should not exceed 14 in. at the top if the posts taper; if not, the opening should not exceed 12 in. The T-section post, from its peculiar shape, is particularly firm in the ground, but above ground it does not look much like a post. The writer suggests for consideration the use of a post of combination section; that is, made up of a T-section below the ground and a D-section above. In this way a maximum of rigidity will be secured, and at the same time a section above ground which resembles in appearance an ordinary post.

The cost of fences erected by contract along the Catskill Aqueduct was approximately as follows:

Line fence with straining post and two braces every 300 ft., and line posts at 16-ft. intervals —

Factory-woven type, 16c to 20c per foot.

Knox or field-woven type, 19c to 22c per foot.

Typical right-of-way, approximately 200 ft. long, with the straining and special posts, braces, and gates incidental thereto, 39c to 42c per foot.

The type of fencing affected the cost of rights-of-way very little.

GROUTING OR CUSHIONING STANDPIPE BASES.

BY CHARLES W. SHERMAN.*

[Read November 10, 1915.]

Probably the most common method of transmitting the pressure from the bottom of a standpipe to the masonry or concrete foundation is by means of a sand cushion or, in some cases, a cushion of sand mixed with cement. Without such a supporting layer it is obvious that the empty tank would rest upon the rivet heads, and when filled the plates between the rivets would be bent in such a way that a considerable part of the plates would come in direct contact with the foundation.

As far as transmitting the loads from the plates to the foundation is concerned, there is no material criticism of the sand cushion. It is a fact, however, that even with the best of workmanship, the bottom of the standpipe is not absolutely flat. Certain plates or parts of plates will bulge either up or down. Those parts which bulge up, or "dome," will not rest upon the sand cushion when the tank is empty, as the sand cannot be caused to flow enough to fill these empty spaces, and the confined air has no opportunity to escape. When the tank is filled with water, the plate is bent down into contact with the sand, but when the tank is emptied the plate will spring back to its original position.

It is, of course, impossible to get at the under side of the bottom of the tank for cleaning and painting, and it is therefore of importance that the material with which the plate comes in contact should have a preservative action upon the metal. It is well known that hydraulic cement has such a preservative action. Probably for this reason it has been customary in many cases to mix dry cement with the sand cushion, on the supposition that in the course of time slight leaks in the bottom plate, or water absorbed from the atmosphere or by capillarity through the foundation, may be sufficient to cause the cement to set. It is obvious,

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however, that if the cement should set, when the tank is empty the domed places in the bottom plate would again spring back to their original position, leaving voids between the metal and the cushion.

As an alternative method, it has been attempted in some cases to grout the space between the bottom plate and the foundation by pouring cement grout through holes left in the bottom plate, these holes being afterward stopped by iron plugs. Although it is somewhat difficult to fill all the voids under the bottom plate by this method, without forcing in the grout under so great a pressure as to lift the bottom plate itself, nevertheless it is possible, by careful work, to substantially fill the entire space. When the bottom is well grouted in this way the plate should be in intimate contact with the cement mortar through its entire extent, and accordingly should be subject to the preservative action of the cement.

This paper has been suggested by a recent experience in grouting the bottom of the new Bird's Hill standpipe for the town of Needham, Mass. This tank is 55 ft. in diameter and 44 ft. in height, and rests on a foundation of cement concrete.

In this case the holes for grouting were arbitrarily spaced 10 ft. apart in both directions. This spacing was unfortunate, as it left a few plates without any grouting holes whatever in them, and in several cases brought the holes close to the seams between the plates. The holes were 2 in. in diameter and were fitted with 2-in. pipe 2 ft. in length and with threaded plugs.

The grout was made of a 1 to 1 mixture of cement and screened sand, using sufficient water to make it of the consistency of cream, and was poured from coal hods into tin funnels inserted in the tops of the pipes. A stick about $\frac{3}{4}$-in. in diameter and somewhat uneven was worked up and down in the grouting pipe while the grout was being poured, thus assisting in keeping the grout well mixed and in causing it to flow freely through the pipe.

The experience in pouring the grout varied considerably. In some cases the grout would flow freely to a long distance from the hole through which it was poured; in others, it could not be made to run more than a short distance. In one case, at least, the grout flowed to a distance of 7 ft. on one side and 8 ft. on the opposite

side of a particular hole. In one case where the grouting hole was located close to a seam the grout apparently did not flow past the seam at all; in another similar case the grout not only passed the seam but flowed freely for a distance of three or four feet beyond it.

It was found practicable to determine closely the extent of the filling beneath the plate by pounding upon the bottom with a heavy stick. When the grout at last ceased to flow from any pipe, it was apparently due to a stoppage at the bottom of the pipe itself, and there was no evidence that hydrostatic pressure was transmitted to any distance around the pipe in such a manner as to tend to lift the bottom plate.

As previously stated, the spacing of the grouting holes was somewhat unfortunate, and we were not successful in completely filling the space beneath the bottom plate from the holes originally drilled. We did, however, succeed in filling nearly all of the space, and used 132 bags of cement in the grout poured through the original 27 holes. By pounding the bottom after this work was completed, the points where additional grouting was required were determined, and were marked. Additional holes are to be drilled at these points and the grouting continued, and we anticipate no difficulty in satisfactorily completing the work.

If the points for the grout pipes had been located upon the bottom in advance of drilling, instead of being arbitrarily placed at a fixed distance apart, there would probably have been no difficulty in completing the job from the first set of holes. The holes should have been so located that there would be at least one in every plate; they should be located approximately axially upon the center line of the plate, and also in the high spots of the bottom, if any exist.

A different method of insuring that the bottom of a standpipe is in perfect contact with the foundation has been employed by Mr. William Wheeler, of Boston, in twelve or fourteen cases, and with entire satisfaction. This method consists in constructing the bottom of the tank in the form of an inverted cone. In Mr. Wheeler's practice the altitude of this cone has been uniformly 2 ft., and this method has been used on tanks as large as 40 ft. in diameter.

It is obvious that the conical form possesses the advantage of being able to resist pressure from beneath, without deformation,

so that it is possible to put in grout under pressure without in any way lifting the bottom, and also that there is no opportunity for air pockets. In setting these tanks it has been Mr. Wheeler's practice to lower them into final position about 2 in. above the previously constructed masonry foundation, and to fill the 2-in. space with a 1 to 1 mortar mixed rather wet and forced into place by a long, thin rammer, working from the outside.

It is interesting to note that Mr. Wheeler had occasion, a few years ago, to raise one of the standpipes constructed in this manner, from its original base, and found the under side of the bottom plates as clean and free from corrosion as when originally received from the mills.

THE WAKEFIELD WATER STERILIZATION PLANT.

BY EDWARD C. SHERMAN.*

[*Read November 10, 1915.*]

The only chlorine gas plant used for the sterilization of a municipal water supply in Massachusetts is the one in Wakefield, which was put in regular use on September 1, 1914, after several weeks of preliminary testing.

Wakefield, with a population of some 13 000, has a surface water supply, taken from Crystal Lake in the outskirts of the town and pumped directly into the mains, a standpipe serving to take the surplus and to afford a night supply, the pumps being run about eight hours a day. A considerable part of the watershed is under cultivation, and much of the resident population is without sewers, so that heavy rains wash a good deal of organic matter into the lake, raising the bacterial content very considerably and at times causing dangerous contamination.

While it is indisputable that filtration is the only method by which such a supply can be rendered always satisfactory in bacterial quality and in appearance, the expense of installing filters was not considered by the water board to be justifiable, as they estimate that the growth of the town will make a new source of supply necessary in from ten to fifteen years. Indeed, it is probable that the capacity of Crystal Lake would have been reached by now had not the introduction of meters on services resulted in checking the waste of water and in reducing the per-capita consumption to about 48 gal. per day.

The board therefore asked me to recommend to them some inexpensive means by which the water could be kept safe for domestic use even though the physical characteristics remained unchanged, provided any such means were available. Sterilization would of course accomplish that result, and I recommended the use of chlorine gas on account of the simplicity of operating the apparatus

* Of Rourke & Sherman, Consulting Engineers, Boston.

and of applying the chemical to the water. My recommendations were adopted and a plant was purchased from the Electro-Bleaching Gas Company of New York.

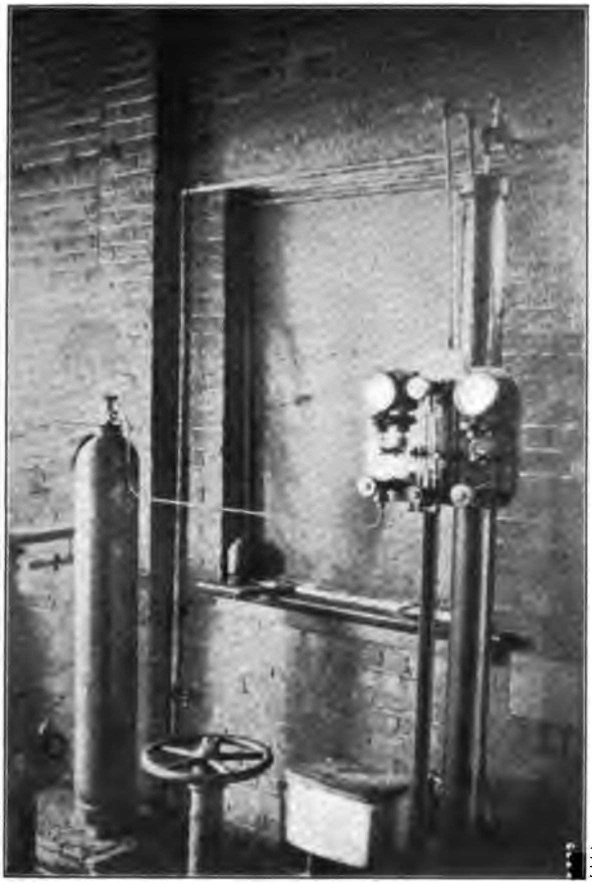
The apparatus consists of a tank, containing chlorine in liquid form; a control board for the necessary valves and gages; and an absorption tower. Opening the valves on the tank and the control panel permits some of the chlorine to vaporize and pass through a copper tube to a reducing valve, where the pressure is changed from the tank pressure of perhaps 100 lb. per sq. in. to 6 or 7 lb. per sq. in. The high and low pressures are shown by gages mounted on the board. The gas then passes through a rate-control valve and enters the tower, where it is absorbed by a small spray of water. The chlorine solution thus formed is then drawn into the suction pipe and is mixed with the supply while passing through the pump.

The rate of pumping being very nearly constant, fluctuations in the consumption being taken care of by the standpipe, the rate of application of the chlorine is satisfactorily controlled by hand, changes in the valve setting seldom being necessary except when required by a change in the quality of the water being treated.

The rate-control gage, which shows the amount of chlorine being used in ounces per hour, consists of a conical glass tube, small end down, containing a peculiarly shaped platinum float which is free to move up and down in it. The gas, in passing upward through the tube, flows through the annular space around the float and raises it to the point where the area of the opening is sufficiently great. The tube is calibrated, and a graduated card, set behind it, indicates the rate of flow for any position of the float. The rate of using the gas is checked by readings of the weight of the tank, which stands on platform scales, and from the records showing the hours of pumping.

A small water tank, provided with a float valve and connected with the absorption tower, maintains a supply of water at a fixed depth in the bottom of the tower. The water for absorbing the chlorine is supplied through a small pipe leading to the top of the tower.

During the first year of the operation of the plant under my direction, — ending September 1, 1915, — 75 samples of raw water and 107 samples of treated water from taps in Wakefield were collected



VIEW OF CHLORINE CONTROL APPARATUS.

and examined. Samples were collected at intervals of from one day to a week, depending on the results of previous analyses and on the weather. The examinations, which were made in the laboratory of Mr. Robert Spurr Weston, indicated that the treated water was continuously safe.

The number of bacteria in the lake water has varied from a minimum of only 30 per c.c. in August, 1915, to a maximum of 1420 per c.c. in January, 1915, just after a hard, warm rain had removed a considerable accumulation of snow and ice from the watershed.

The number of bacteria in the treated water has seldom been above 30 per c.c., the maximum being 56 and the minimum 1 per c.c. In January, on the day when the lake was in its worst condition, we found only 16 per c.c. in the treated water. For the year the averages were, for Crystal Lake, 254 per c.c., and for the supply as delivered to the consumers, 18 per c.c., — an average removal of 93 per cent.

The averages for each month were as shown in the following table.

Year.	Month.	Crystal Lake.		Tap Water.	
		Number of Samples.	Average No. of Bacteria per c.c.	Number of Samples.	Average No. of Bacteria per c.c.
1914	September	12	89	16	10
	October	5	81	10	16
	November	4	81	5	16
	December	6	56	10	9
1915	January	17	625	19	14
	February	10	220	11	24
	March	4	181	9	33
	April	4	149	6	23
	May	3	172	5	24
	June	2	285	4	15
	July	4	308	6	31
	August	4	111	6	16

B. coli were found in 17 per cent. of the raw water samples and in none of the treated water samples, the counts being made on 10 c.c.

To secure these results the amount of chlorine has varied from

a minimum of one part to 2 000 000 parts of water, in December, 1914, to a maximum of 1 part in about 800 000 parts of water for a very short time in January, 1915. The water at this time contained a large amount of organic matter, much of it of a harmless

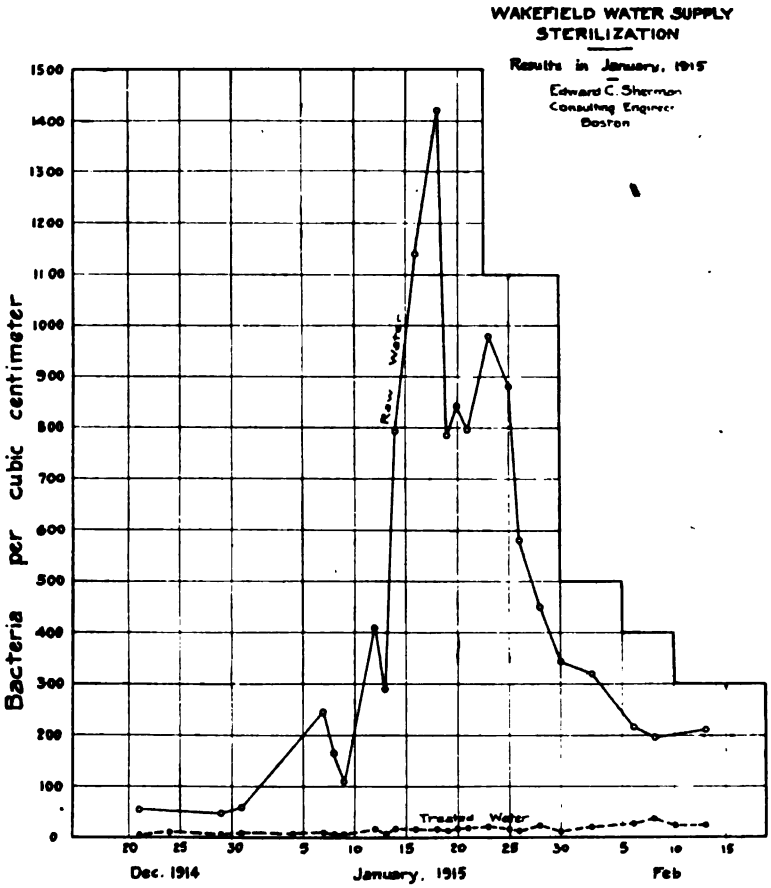


FIG. 1.

nature, but it made necessary an unusually large dose of disinfectant in order to get the desired effect on the bacteria. If the water could be clarified by rapid filtration prior to the sterilization, it is probable that even better results could be secured and with less chlorine.

The cost of the plant in place was about $600. The present cost of operating it, including chlorine, supervision of operation, and interest is approximately $1.25 per million gallons. For the year, and including the cost of the almost constant supervision when the plant was first started and at times when the raw water was bad, the cost averaged about $1.75 per million gallons.

Although the results of the use of chlorine have been good in Wakefield, it must be remembered that no method of sterilization can remove turbidity or much of the color, so it can never take the place of filtration. Of the cynical who may advance the argument that the success of the treatment is dependent on the faithfulness and intelligence of those in charge, I can only ask if it is not equally true of any other kind of a purification plant. No purification plant will run itself, and the human element must always be considered. However, as it is becoming increasingly more difficult to secure adequate natural supplies of pure water, processes of artificial purification are absolutely necessary and I am convinced that sterilization has its proper place among them and that it is especially valuable for small surface-water supplies, where conditions do not justify the expense of filtration.

DISCUSSION.

MR. JOHN A. KIENLE* (*by letter*). With regard to Mr. Sherman's statement near the end of his paper, that no method of sterilization can remove much color, I wish to call attention to the results which Mr. Robert Spurr Weston obtained at Exeter, N. H., where by the use of liquid chlorine he was enabled to save a considerable quantity of alum which was used there in the filtration plant for the reduction of color, and that by using the chlorine the color was rendered decidedly better than that obtained previously by the use of alum. The results obtained are shown in the following brief tabulation taken from the September, 1914, issue of the American Water Works Association.

	June. 1913.	June. 1914.
Color, reservoir	90.0	75.0
Color, effluent	45.0	6.0

* Sanitary Engineer, New York.

A similar experience is reported from St. Catharines, Ont., Mr. Milne advising me that there has been quite a noticeable reduction in the color of the water. I believe that, if this matter were further investigated by competent engineers and chemists, some very interesting data could be obtained. Many of the chlorine gas plants which have been installed are not under scientific supervision, and matters of this kind are seldom considered.

The costs given by Mr. Sherman for sterilizing the Wakefield water are rather higher than the average cost for other plants, due to the high organic content of the Wakefield supply, which necessitates an excessive quantity of chlorine. It is seldom that with raw, unfiltered waters it is necessary to use more than three or four pounds of liquid chlorine per million gallons, giving a cost of less than 50 cents per million gallons; while on filtered waters the average quantity used is less than two pounds per million gallons, corresponding to a maximum cost of about 25 cents per million gallons.

Mr. Robert S. Weston.* I might say, in explanation of Mr. Kienle's criticism or discussion, that the two cases, the one at Wakefield and the one at Exeter, are hardly parallel. At Wakefield, chlorine is added to water and nothing further done to it. At Exeter, chlorine is added to the water; then sulphate of alumina is added, and the whole is filtered. While it is true, as Mr. Kienle says, that the addition of chlorine makes better color reduction possible, it is not true that if chlorine alone were added to the Exeter water there would be an appreciable reduction of color unless the water was treated and filtered afterwards.

Mr. Caleb M. Saville.† Our experience at Hartford with chlorine gas is that there was quite a little reduction in color.

I would like to ask Mr. Sherman if he had any trouble with aftergrowths in tap water. I would also like to ask what the temperature of the room was in which his apparatus is located, and whether or not he has noticed any differences in the efficiency of the apparatus with variation of temperature.

Mr. Sherman. In regard to Mr. Kienle's remarks about color removal, we have not made any examinations of the color of the Wakefield water, as it has not been of particular interest. The

* Of Weston & Sampson, Consulting Engineers, Boston.

† Chief Engineer, Water Commission, Hartford, Conn.

sole object of the use of chlorine there has been to reduce the number of bacteria and thereby to make a water which, while not particularly good in appearance, is nevertheless safe to use for drinking. And that I believe we have done. Mr. Kienle also speaks of the amount of chlorine used in Wakefield as excessive compared with some of his figures. It is, perhaps, but we have never had to use an amount which could be detected in the water by taste or smell. His statement that fifty cents per million gallons is a reasonable cost seems to me to be based on the cost of the chlorine only. Now Wakefield has had to pay for the chlorine, of course, but in order to feel sure that we were getting good results, the town has also paid for a large number of analyses, which, of course, are rather expensive, and for engineering supervision, which very few plants, as Mr. Kienle says, have.

In answer to Mr. Saville's inquiry about after-growths, I have not noticed that there has been any trouble in that way. Chlorine is applied to the water just before it goes into the pumps, from which it goes immediately to the mains, and the samples have shown a large and very satisfactory reduction of bacteria. The temperature in the pumping station must be between 80 and 90 degrees, I think, although I have not read a thermometer there. It is always very warm. I am not able to say whether the efficiency is affected by that or not, because the only records that I have are bacterial counts of samples of the raw water and of the treated water taken at the same time.

The efficiency has been about 93 per cent. for the year. This method of recording efficiency by percentages is in some ways unsatisfactory. I think 93 per cent. would perhaps sound low to a filter man who expects to get a removal of 98 or 99 per cent. of the bacteria. If the raw water contains a thousand bacteria per cu. cm. it is easy to get a 99 per cent. reduction, whereas when there are only 200 it is exceedingly difficult.

MR. FRANK L. FULLER.* I would like to inquire whether there is any appreciable precipitation due to this treatment.

MR. SHERMAN. I do not see why any should be caused, but there is no way we can tell because the water goes on into the mains and we have no way of measuring it.

* Civil Engineer, Boston.

MR. SAVILLE. Mr. Sherman's apparatus is apparently very favorably situated, and he should have very good results from it. The apparatus that we have at Hartford is located in a small building by itself, and we found that we had to have artificial heat there with it for a great part of the time in order to get the best results.

MR. SHERMAN. The minor water supply which absorbs the chlorine is not warmed except as it may be by passing through a small pipe in the pumping station for a short distance. It flows very slowly, and it may be that the temperature is raised a very little, but I should not imagine that in winter it would be warmed appreciably.

PROCEEDINGS.

Annual Meeting.

Hotel Brunswick,
Boston, Mass., January 12, 1916.

The President, Leonard Metcalf, in the chair.
The following members and guests were present:

Honorary Members.

E. C. Brooks, G. A. Stacy, R. C. P. Coggeshall, A. S. Glover, F. E. Hall, F. P. Stearns. — 6.

Members.

C. L. Baker, L. M. Bancroft, F. S. Bailey, F. A. Barbour, A. E. Blackmer, J. W. Blackmer, George Bowers, Bertram Brewer, James Burnie, George Cassell, J. C. Chase, F. L. Clapp, E. S. Cole, J. E. Conley, John Cullen, J. M. Diven, H. P. Eddy, E. D. Eldredge, A. L. Fales, S. F. Ferguson, G. H. Finneran, F. F. Forbes, Patrick Gear, F. J. Gifford, T. C. Gleason, R. K. Hale, J. O. Hall, D. A. Heffernan, J. L. Howard, A. C. Howes, G. A. Johnson, H. R. Johnson, W. S. Johnson, E. W. Kent, Willard Kent, T. E. Lally, J. B. Longley, E. J. Looney, F. A. McInnes, Hugh McLean, H. V. Macksey, W. E. Maybury, John Mayo, J. H. Mendell, F. E. Merrill, Leonard Metcalf, H. A. Miller, J. W. Murphy, William Naylor, A. S. Negus, T. A. Pierce, C. E. Perry, H. G. Pillsbury, L. C. Robinson, P. R. Sanders, C. M. Saville, C. W. Sherman, E. C. Sherman, H. M. Sinclair, M. A. Sinclair, G. Z. Smith, Sidney Smith, G. H. Snell, C. M. Spofford, F. O. Stevens, W. F. Sullivan, H. A. Symonds, R. J. Thomas, Milton Thorne, J. L. Tighe, A. H. Tillson, D. N. Tower, W. J. Turnbull, J. H. Walsh, R. S. Weston, J. P. Wentworth, G. C. Whipple, O. J. Whitney, F. I. Winslow, G. E. Winslow, I. S. Wood. — 81.

Associates.

Harold L. Bond & Co., G. S. Hodges; Builders Iron Foundry, A. B. Coulters and F. N. Connet; A. M. Byers Co., H. F. Fiske; Chapman Valve Mfg. Co., V. N. Bengle and J. T. Mulgrew; Darling Pump and Mfg. Co., H. A. Snyder; Eddy Valve Co., H. W. Dotten and John Knickerbacker; F. H. Hayes Machinery Co., F. H. Hayes; Hersey Mfg. Co., A. S. Glover and J. Herman Smith; Lead Lined Iron Pipe Co., T. W. Dwyer; Ludlow Valve Mfg. Co., A. A. Taylor

and G. A. Miller; H. Mueller Mfg. Co., G. A. Caldwell; National Meter Co., H. L. Weston; Neptune Meter Co., H. H. Kinsey; Norwood Engineering Co., H. W. Hosford and F. M. Sears; Rensselaer Valve Co., C. L. Brown and F. S. Bates; A. P. Smith Mfg. Co., F. L. Northrop; Thomson Meter Co., S. D. Higley and E. M. Shedd; Union Water Meter Co., F. E. Hall; Water Works Equipment Co., W. H. Van Winkle; R. D. Wood & Co., H. M. Simons; Henry R. Worthington, Samuel Proctor and W. F. Bird. — 30.

GUESTS.

Thomas F. Dorsey, Edgartown, Mass.; James Kinloch, E. Greenwich, R. I.; Walter Skinner, secretary board of health, Braintree, Mass.; Mr. Collins, Cambridge, Mass.; John A. Carter, Malden, Mass.; F. W. Mathers, Boston; Mass.; G. E. Gormley, Abington, Mass.; George N. Buckhont, Newport, R. I., D. J. Dever, H. D. Coombs, H. S. O'Brien, J. P. Perham, Boston, Mass.; Wm. J. Murray, Rumford, R. I.; Wm. A. Bradford, president South Shore Water Plant, Quincy, Mass.; Mr. Putnam, Lowell, Mass.; C. F. Gettemy, State Board of Statistics, Boston, Mass.; Theodore M. Waddell, Boston, Mass. — 17.

The Secretary presented the following applications for membership, properly endorsed and recommended by the Executive Committee:

E. D. Bistline, Newport, Pa., secretary of Hanover & Washington Water Co., Newport Home Water Co., Lebanon Valley Consolidated Water Supply Co., Middletown & Swatara Consolidated Water Co., and other water companies; Edward G. Gushee, Philadelphia, Pa., 2d assistant engineer, Bureau of Water, Philadelphia; George Mitchell, Aberdeen, Scotland, engaged exclusively on water works for twenty-two years, at present principal assistant to city water engineer on a scheme costing £500,000; Fred B. Nelson, New York City, civil and hydraulic engineering; William G. Newhall, Portland, Me., assistant superintendent Portland Water District; James A. Steele, Jr., Vicksburg, Miss., water works for past ten years, at present manager of city water works, Vicksburg, Miss.; Edward Mayo Tolman, Charleston, W. Va., health departments of Massachusetts, Maryland, and West Virginia, chief engineer state department of health, W. Va.; Joseph F. Ranger, Holyoke, Mass., water commissioner, Holyoke, Mass.; Raymond Walker, Edgartown, Mass., superintendent Edgartown Water Co.; John P. Wentworth, Malden, Mass., assistant engineer, Metcalf & Eddy, Boston, Mass.

On motion, duly seconded, the Secretary was directed to cast the ballot of the Association in favor of the applicants, and he having done so they were declared duly elected members of the Association.

Report of the Executive Committee.

The President, Mr. Leonard Metcalf, for the Executive Committee, presented the following:

REPORT UPON THE ACTIVITIES OF THE NEW ENGLAND WATER WORKS ASSOCIATION DURING THE YEAR 1915.

Membership.

The Secretary's report indicates that we have now a membership only 39 less than a full thousand.

It is perhaps interesting to note the changes in rate of growth of the Association during various periods. As will be seen from the diagram before you, during the first seventeen years the net rate of increase was fairly uniform, averaging 34 members per year; during the next six years there were considerable losses, due mainly to the increase in annual dues from $2 to $3, and the average net increase was but 5 members per year; then for nine years the increase averaged 17 per year, while during the past two years the average growth has been 102. For the whole 34 years the average net rate of increase was 28 members per year. A considerable portion of the gain for the past year (114) resulted more or less directly from the action of the Association in abating the entrance fee for members of the American Water Works Association joining in the year 1915. Ninety-two members and 8 associates, or 100 in all, took advantage of this offer.

It is believed, however, that the work of the Association is not as thoroughly appreciated, by water departments and water boards in many of the smaller communities of New England, as it should be; and that further effort, which must be largely of a personal nature, could and should be made, in the interest alike of the public and of the Association, to reach these men and boards, with a view to further extending the activities and usefu work of the Association.

Deaths.

The Association has lost, by death, during the year, the following members: H. H. Barnes, Dexter Brackett, Eben R. Dwyer, E. A. Ellsworth, John H. Flynn, W. A. McFarland, Thomas F. Richardson, J. Herbert Shedd, J. F. Sprenkell, Francis P. Washburn, and E. P. Whitten.

Meetings.

The usual number of meetings has been held and the attendance has been good. The June field day took the form of a joint excursion with the Boston Society of Civil Engineers; and a ball game between teams, representing the two associations, was an important feature. This contest was much enjoyed, and it is believed that a similar plan for future excursions may be advantageous.

The annual convention in New York was very successful, thanks to the efficient work of the able local committee, headed by Alfred D. Flinn, and the friendly coöperation with it of the associates and the Manufacturers Association representatives. The papers were largely of a practical nature and were well received, and the exhibits were excellent.

Papers.

It has been the constant endeavor of your officers to secure papers which should be thoroughly practical. They recognize that the Association exists primarily for the benefit of men engaged in the actual operation of water works, and that the scientist and engineer fit into its activities only as they help along water-works science and art and draw out from the practical water-works men their experiences in the building and operation of water works, which may be of value to their fellow-men.

Committees.

The past reputation of this Association has been won, in considerable measure, by the work of its committees. The work done during the past year compares favorably with that of other years, although none of the existing committees has made its final report

during this period. A brief reference to the work of these committee is perhaps desirable.

The committee on FILTRATION STATISTICS (G. C. Whipple, chairman) made a report which was accepted, in which was outlined a standard form for recording statistics of filter operation. The committee was continued, to work for the adoption and use by filtration plants of the proposed forms. It reports good progress in this direction.

The committee on METER RATES (Allen Hazen, chairman) made a very valuable report, covering the question of rates in an admirable manner. It was continued in order to consider the question of "water-unaccounted-for," and will probably report upon that subject at an early meeting, rendering its final report at that time.

The committee on CAST-IRON PIPE SPECIFICATIONS (F. A. McInnes, chairman), which has been in existence for several years, has devoted itself to an attempt to secure concerted action with a similar committee of the American Water Works Association. Marked advance has been made in bringing the two committees together, to the end of unifying views, and it is believed that substantial progress toward final report will be made in the near future.

The committee on STANDARD HYDRANT SPECIFICATIONS (H. O. Lacount, chairman) reported in 1914 and the suggested specifications were adopted, with the exception of two or three clauses which were referred back to the committee for further consideration. The chairman of the committee reports that effort has been made to get the coöperation of the manufacturers, in presenting or developing further information concerning the size of the valve and the amount of friction loss in hydrants of various makes, without success, and desires expression of opinion as to the further wishes of the Association. It is suggested that further effort be made to obtain the active coöperation of the manufacturers, or, failing in this, that the Association take early action upon the specifications, as outlined by the committee, with a view to advantageous standardization of practice as far as this may prove possible.

The committee on SERVICE PIPES (William S. Johnson, chair-

man) has obtained and tabulated a large amount of information relative to practice in different places and the experiences had with service pipe made of different materials. The data are being analyzed in an attempt to determine the reasons for the variety of experience recorded.

The committee on LEAKAGE FROM PIPE JOINTS (F. A. Barbour, chairman) was appointed in September, and has not yet had time to make marked progress. It has, however, outlined the form of circular to be used in obtaining information, which will be issued in the near future. Members are urged to coöperate conscientiously with the committee, by prompt compliance with requests for information and by furnishing as complete data as possible. The work which the committee is undertaking is of great importance to members of this Association and the public, but its results can be of value only if the necessary information is furnished to the committee.

The committee on BRACKETT MEMORIAL (Frederic P. Stearns, chairman), appointed to procure the necessary funds and to draft rules for the award of a bronze medal to be given annually for the most meritorious paper presented, as a memorial to past-president Dexter Brackett, report that a sufficient fund has already been guaranteed by a few of the members of the Association to assure the success of the memorial, and there will soon be given to the entire membership opportunity to contribute to this memorial which, it is believed, will be welcomed. The contributions are to be purely voluntary and of such amount only as the donors may feel impelled to make. It is thought that Mr. Brackett himself would have felt that no better type of memorial than this could have been suggested.

The Executive Committee has given careful consideration to the subject of LEGISLATIVE COMMITTEES, referred to it at the last meeting. It recommends, however, that action be deferred until the new Executive Committee can consider the subject, and in the meantime it will submit to the new board its tentative conclusions.

Pan-American Scientific Congress.

The Association was represented at the Second Pan-American Scientific Congress, which has just concluded its session at Wash-

ington, by Mr. Alfred D. Flinn, who not only participated in the meetings of the engineering section of the Congress, but presented a paper on " Reservoirs for Municipal Water Supply."

Journal.

This year's volume of the JOURNAL has been the largest since 1910, and is the next to the largest ever published by the Association. It contains 26 papers, some of which were presented at the 1914 convention. It is especially noteworthy as containing Mr. X. H. Goodnough's paper upon " Rainfall in New England." The cost of printing this paper and the report of the committee (of which Mr. Frederic P. Stearns was chairman) upon " Yield of Drainage Areas " was very large, as the former covered 201 pages, chiefly of tabular statistics, and the latter 74 pages, containing many tabulations and diagrams, so that the year's volume has been an unusually expensive one, involving an additional cost of upwards of one thousand dollars. Nevertheless, the publication of these papers is believed to have been fully justified and of great value to the public and those particularly interested in the subjects covered. The excessive cost, which results in a deficit for the year's operations, should therefore not be a matter of regret.

The increased circulation of the JOURNAL, from 953 to 1 079, due to the increase in membership, also involved increased expense.

In a report to your President, the editor, Mr. Richard K. Hale, states that with the present number of meetings and the type of papers presented, it is probable that the size of the JOURNAL will average nearly 600 pages in the future. The committee reports are nearly always expensive, but they have been very valuable to the Association, its members and the public, so that the portion of the annual dues of members, which should be attributable to the JOURNAL, is likely to average more than $1.50 per member as time goes on, unless something is done to increase the revenue. The revenue increase can be reached in two ways, by increase of dues or by increase in advertising. Both of these subjects could be discussed with profit, by the Executive Committee, which will soon be compelled to act upon them.

Finances.

As reported in detail by the Treasurer, Lewis M. Bancroft, the cash balance on hand at the beginning of the year was $3,645.51; the general current receipts for the year amounted to $7,123.84; the interest on bonds and deposits, $214.72, — a total of $7,338.56; the expenditures to $8,569.16; leaving a cash balance on hand at the end of the year of $2,414.91.

The decrease in cash balance is attributable, as already stated, wholly to the excessive cost of the JOURNAL, due to the statistical data contained in two important and valuable papers. Since the Association has received an equivalent in value for the expenditure of these funds, there would seem to be no cause for anxiety over the decrease, as the publication of such statistical reports is not of annual occurrence.

Respectfully submitted,

LEONARD METCALF,
For the Executive Committee.

The Secretary, Mr. Willard Kent, presented his annual report as follows:

REPORT OF THE SECRETARY.

JANUARY 1, 1916.

Mr. President and Gentlemen of the New England Water Works Association,— The Secretary submits herewith the following report of the changes in membership during the past year, and the general condition of the Association.

The present membership is 961, constituted as follows: 18 Honorary, 862 Members, and 81 Associates. That of one year ago was 847, comprised of 11 Honorary, 766 Members, and 70 Associates. A net gain for the year of 114. The detailed changes are as follows:

MEMBERSHIP.

January 1, 1915.	Honorary Members	11		
	Transferred from "Members"	7		
		——		18
January 1, 1915.	Total Members		766	
	Withdrawals:			
	Resigned	26		
	Dropped	13		

	Died	11			
			50		
	Transferred to " Honorary Members "		7	57	
				709	
	Initiations:				
	January	7			
	February	5			
	March	2			
	June	76			
	September	34			
	November	13			
	December	8			
			145		
	Reinstated:				
	Members resigned in '99	1			
	,, ,, ,, '05	1			
	,, ,, ,, '14	2			
	,, dropped in '05	2			
			6		
	Elected 1914, qualified 1915		2	153	
					862
January 1, 1915.	Total Associates		70		
	Withdrawals:				
	Resigned		1		
				69	
	Initiations:				
	June	1			
	September	8			
	November	1			
			10		
	Reinstated:				
	Associate resigned in '13	1			
	,, ,, ,, '14	1	2	12	
					81
January 1, 1916.	Total membership				961
January 1, 1915.	Total membership				847
	Net gain				114

The Secretary has received and paid to the Treasurer, $7 123.84.

Of this amount the
Receipts for initiation fees were $274.00

From dues of members	$2 560.50		
From dues of members, fractional	41.50		
From dues of members, past	21.00		
		$2 623.00	
From dues of Associates	$1 050.00		
From dues of Associates, fractional	61.50	1 111.50	
Total from dues			$3 734.50
From advertisements			1 755.00
From subscriptions			213.00
From JOURNALS			142.26
From sundries			1 005.08
Total as above			$7 123.84

There is due the Association at this date:

For advertising	$30.00
For specifications	.30
For certificate	1.50
For subscriptions	18.00
Total amount due	$49.80

Respectfully submitted,

WILLARD KENT, *Secretary.*

REPORT OF THE TREASURER.

The Treasurer, Mr. Lewis M. Bancroft, submitted the following report:

CLASSIFICATION OF RECEIPTS AND EXPENDITURES.

Receipts.

Dividends and interest		$220.61
Initiation fees	$274.00	
Dues	3 734.50	
Total received from members		4 008.50
JOURNAL:		
Advertisements	$1 755.00	
Subscriptions	213.00	
Sale of JOURNALS	142.26	
Sale of reprints	42.00	
Total received from JOURNAL		2 152.26

NEW ENGLAND WATER WORKS ASSOCIATION.

Year	President.	Membership at End of Year.				Annual Convention.		Receipts for Year.	Expenditures for Year.	Total Balance at End of Year.
		Members.	Associate.	Honorary.	Total.	Place.	Date.			
1882	(Organized)	27	—	—	27	Boston, Mass.	June 21, '82			
1882–3	*James W. Lyon	37	6	—	43	Worcester, Mass.	June 21, '83	$245.00	$87.86	$157.14
1883–4	Frank E. Hall	48	9	—	57	Lowell, Mass.	June 19–20, '84	156.14	171.90	141.38
1884–5	*George A. Ellis	83	44	—	127	Springfield, Mass.	June 18–19, '85	651.84	511.44	281.78
1885–6	R. C. P. Coggeshall	106	47	—	153	New Bedford, Mass.	June 16–18, '86	1 658.50	1 643.42	296.86
1886–7	*Henry W. Rogers	137	52	2	191	Manchester, N. H.	June 15–17, '87	1 342.28	1 066.98	572.16
1887–8	*Edwin Darling	181	54	3	238	Providence, R. I.	June 13–15, '88	2 013.30	1 697.15	888.31
1888–9	*Hiram Nevons	209	64	4	277	Fall River, Mass.	June 12–14, '89	2 204.07	2 127.70	964.68
1889–90	*Dexter Brackett	257	73	5	335	Portland, Me.	June 11–13, '90	2 511.27	2 346.65	1 129.30
1890–1	*Albert F. Noyes.	281	74	5	360	Hartford, Conn.	June 10–12, '91	3 055.13	1 884.78	2 299.65
1891–2	*Horace G. Holden	290	70	5	365	Holyoke, Mass.	June 8–10, '92	2 887.17	3 278.54	1 908.28
1892–3	*George F. Chace	338	69	5	412	Worcester, Mass.	June 14–16, '93	3 422.61	3 317.22	2 013.67
1893–4	*Geo. E. Batchelder	365	73	5	443	Boston, Mass.	June 14–16, '94	3 208.85	3 259.07	1 963.45
1894–5	George A. Stacy	401	81	5	487	Burlington, Vt.	Sept. 11–13, '95	3 147.41	3 115.99	2 673.03
1895–6	Desmond FitzGerald	442	82	5	529	Lynn, Mass.	June 10–12, '96	3 179.91	3 148.49	2 704.45
1896–7	*John C. Haskell	464	80	5	549	Newport, R. I.	Sept. 8–10, '97	3 340.23	3 322.94	2 271.74
1897–8	Willard Kent	488	77	5	570	Portsmouth, N. H.	Sept. 14–16, '98	3 002.13	2 786.95	2 936.92
1898–9	Fayette F. Forbes	494	73	5	572	Syracuse, N. Y.	Sept. 13–15, '99	2 825.71	3 050.23	2 712.40
1899–1900	Byron I. Cook	519	70	5	594	Rutland, Vt.	Sept. 19–20, '00	4 920.49	5 524.65	2 108.24
1901	Frank H. Crandall	493	58	4	555	Portland, Me.	Sept. 18–20, '01	4 238.55	4 283.22	2 063.57
1902	Frank E. Merrill	522	60	5	587	Boston, Mass.	Sept. 10–12, '02	5 158.48	4 680.32	2 541.73
1903	*Charles K. Walker	520	55	3	586	Montreal, Canada	Sept. 9–11, '03	5 032.40	4 505.08	3 069.05
1904	Edwin C. Brooks	538	58	8	604	Holyoke, Mass.	Sept. 14–16, '04	5 328.31	5 528.21	2 869.15
1905	George Bowers	584	53	8	645	New York, N. Y.	Sept. 13–16, '05	5 431.16	5 411.58	2 888.73
1906	Wm. T. Sedgwick	618	51	15	684	White Mts., N. H.	Sept. 12–14, '06	5 366.94	4 845.14	3 410.53
1907	John C. Whitney	636	51	15	692	Springfield, Mass.	Sept. 11–13, '07	5 291.83	4 222.06	4 480.30
1908	Alfred E. Martin	633	49	14	696	Atlantic City, N. J.	Sept. 23–25, '08	5 706.36	7 475.56	†2 711.10
1909	Robert J. Thomas	647	55	13	715	New York, N. Y.	Sept. 8–10, '09	5 305.31	4 566.84	†3 449.57
1910	George A. King	678	56	13	747	Rochester, N. Y.	Sept. 21–23, '10	6 507.08	7 237.60	†2 719.05
1911	Allen Hazen	680	58	12	750	Gloucester, Mass.	Sept. 13–15, '11	6 440.90	6 279.72	†2 880.23
1912	Geo. W. Batchelder	666	53	12	731	Washington, D. C.	Sept. 18–20, '12	6 861.65	5 934.56	†3 807.32
1913	J. Waldo Smith	686	60	12	758	Philadelphia, Pa.	Sept. 10–12, '13	6 122.81	6 533.62	†3 396.51
1914	Frank A. McInnes	766	70	11	847	Boston, Mass.	Sept. 9–11, '14	7 686.17	7 437.17	†3 645.51
1915	Leonard Metcalf	862	81	18	961	New York, N. Y.	Sept. 7–9, '15	7 338.56	8 569.16	§2 414.91

*Deceased. †Does not include $1 815 invested in bonds.

Miscellaneous receipts:			
Sale of " Pipe Specifications "		$20.00	
Dinners		837.00	
Certificates of membership		34.50	
Buttons		2.25	
Miscellaneous		63.44	
Total miscellaneous receipts			$957.19
Total receipts			$7 338.56

Expenditures.

JOURNAL:			
Advertising agent, commission		$225.90	
Plates		187.93	
Printing		3 453.60	
Editor's salary		375.00	
Expense		48.42	
Advance reports		19.00	
Reporting		297.20	
Reprints		160.50	
Envelopes, postage, and mailing		74.88	
			$4 842.43
Office:			
Secretary, salary		$200.00	
Expense		26.35	
Assistant Secretary, salary		600.00	
Expense		293.22	
Rent		400.00	
Printing, stationery, and postage		417.76	
Membership lists		212.75	
			2 150.08
Meetings and Committees:			
Stereopticon		$50.00	
Dinners	$867.50		
Cigars	57.10		
Music	105.00		
Extra menu	10.00		
		1 039.60	
Printing, stationery, and postage		299.11	
Badges		15.14	
Tracings		6.00	
			1 409.85
Treasurer's salary and bond			67.50
Certificates of membership			51.30
Miscellaneous			48.00
			$8 569.16

LEWIS M. BANCROFT, *Treasurer*,
In account with the New England Water Works Association.

RECEIPTS.

1915.			
Jan. 1.	Balance on hand		$3 645.51
	Received of Willard Kent, Secretary		7 123.84
	Interest on bonds and deposits		214.72
			$10 984.07

EXPENDITURES.

Bills paid		$8 569.16
BALANCE ON HAND.		
People's Savings Bank	$2 000.00	
Mechanics Savings Bank	372.96	
First National Bank	40.68	
Liberty Trust Co.	1.27	
		2 414.91
		$10 984.07

ASSETS AND LIABILITIES.

ASSETS.

Cash, balance in banks		$2 414.91
Bonds Nos. 2642 and 2644, Lake Shore & Mich. So. R. R. 4%, due May 1, 1931. Book value, 1 815.00. Market value		1 887.40
Accounts receivable:		
JOURNALS	$18.00	
Advertising	30.00	
Specifications	.30	
Certificates	1.50	
		49.80
		$4 352.11

LIABILITIES.

Accounts payable:	
Rent	$100.00
Surplus	4 252.11
	$4 352.11

READING, January 8, 1916.

LEWIS M. BANCROFT, *Treasurer.*

The Editor, Mr. Richard K. Hale, submitted the following report:

Report of the Editor.

Boston, January 12, 1916.

To the New England Water Works Association, — I present the following report for the Journal of the New England Water Works Association for the year 1915.

The accompanying tabulated statements show in detail the amount of material in the Journal; the receipts and expenditures on account of Volume XXIX (1915), and a comparison with the conditions of preceding years.

Size of Volume. — With the exception of Volume XXIV, this is the largest volume yet published.

Illustrations. — The total cost of illustrations for the year, including printing, has been $406.43, or 9.6 per cent. of the gross cost of the volume, which is about the average.

Reprints. — The usual number of reprints has been furnished to authors without charge, and additional reprints when desired have been furnished at cost. The net cost to the Association on this account has been $160.50, which is about normal.

Advance Copies. — Advance copies of one paper only have been published, at a cost of $10.50.

Advertisements. — There has been an average of 25 pages of paid advertising, with an income of $1 755, a considerable increase over last year.

Circulation. — The present circulation of the Journal is:

Members	961
Subscribers	87
Exchanges	31
Total	1 079

an increase of 126 over the preceding year. Journals have also been sent to 43 advertisers.

Pipe Specifications. — During the year specifications to the value of $20.20 have been sold. None has been printed during the year. The net gain up to a year ago had been $274.05, so that the total gain net from this source to date is $294.25. There are on hand about 225 copies.

The Association has a credit of $4.19 at the Boston Post-Office, being the balance of the money deposited for payment of postage upon the Journal at pound rates.

There are no outstanding bills, on account of the Journal, which are not included in these tables.

Respectfully submitted,

RICHARD K. HALE, *Editor.*

TABLE 1.

STATEMENT OF MATERIAL IN VOLUME XXIX, JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION, 1915.

Number.	Date.	Pages of Papers.	Proceedings.	Total Text.	Index.	Advertisements.	Cover and Contents.	Inset Plates.	Total Pages.	Total Cuts.
1	March	120	27	147	1	28	4	2	182	4
2	June	77	11	88	1	28	4	20	141	39
3	September	202	41	243	1	28	4	3	279	9
4	December	96	22	118	8	31	4	13	174	29
	Total	495	101	596	11	115	16	38	776	81

TABLE 2.

RECEIPTS AND EXPENDITURES ON ACCOUNT OF VOLUME XXIX, JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION, 1915.

Receipts.		*Expenditures.*	
Advertisements	$1 755.00	Printing JOURNAL	$2 757.94
Sale of JOURNALS	142.26	Printing illustrations	212.50
Sale of reprints	42.00	Preparing illustrations,	193.93
Subscriptions	213.00	Editor's salary	300.00
		Editor's incidentals	37.23
	$2 152.26	Advertising agent's commissions	231.35
Net cost of volume	2 091.09	Reporting	297.40
		Reprints	202.50
		Advance copies	10.50
	$4 243.35		$4 243.35

TABLE 3.

COMPARISION BETWEEN VOLUMES XX TO XXIX, INCLUSIVE, NEW ENGLAND WATER WORKS ASSOCIATION.

	Vol. XX. 1906.	Vol. XXI. 1907.	Vol. XXII. 1908.	Vol. XXIII. 1909.	Vol. XX V. 1910.	Vol. XXV. 1911.	Vol. XXVI. 1912.	Vol. XXVII. 1913.	Vol. XXVIII. 1914.	Vol. XXIX. 1915.
Average edition (copies printed)	900	1 085	1 000	1 000	1 150	1 000	1 000	1 000	1 050	1 325
Average membership	665	693	699	710	732	752	740	745	803	904
Circulation at end of year	767	785	780	802	827	840	826	858	951	1 079
Pages of text	495	500	500	459	643	475	401	554	564	596
Pages of text per 1 000 members	745	722	715	646	880	632	542	746	702	659
Total pages, all kinds	662	669	681	627	808	654	567	733	719	776
Total pages per 1 000 members	995	964	976	884	1 090	870	766	984	895	859
GROSS COST:										
Total	$2 573.61	$2 643.42	$2 733.61	$3 111.15	$3 490.81	$2 625.87	$2 476.55	$3 586.29	$3 345.87	$4 243.35
Per page	3.88	3.95	4.01	4.97	4.32	4.02	4.37	4.89	4.65	5.47
Per member	3.87	3.82	3.91	4.39	4.78	3.50	3.35	4.81	4.17	4.68
Per member per 1 000 pages	5.85	5.70	5.88	7.00	5.90	4.09	5.90	6.46	5.80	6.02
Per member per 1 000 pages text	7.81	7.62	8.02	9.56	7.44	7.36	8.35	8.68	7.39	7.85
NET COST:										
Total	$387.96	$483.15	$131.06	$789.98	$1 334.06	$352.82	$98.81	$1 322.90	$1 155.33	$2 091.09
Per page	.58	.72	.19	1.26	1.65	.54	.17	1.80	1.61	2.70
Per member	.58	.70	.19	1.11	1.82	.47	.13	1.78	1.44	2.32
Per member per 1 000 pages	.88	1.04	.28	1.78	2.25	.55	.23	2.42	2.00	2.98
Per member per 1 000 pages text	1.18	1.39	.39	2.43	2.83	.98	.33	2.38	2.55	3.88

TABLE 4.

COMPARISON OF THE MATERIAL IN VOLUMES XX TO XXIX INCLUSIVE.

Year.	Total Text.	Miscellaneous.	Advertisements.	Plates.	Total Pages.	Total Cuts.
1906	495	23	115	29	662	41
1907	500	24	125	20	669	97
1908	500	24	118	39	691	47
1909	459	23	108	37	627	28
1910	643	28	119	18	808	38
1911	475	25	128	26	654	57
1912	401	24	120	22	567	53
1913	554	27	117	35	733	118
1914	564	23	119	13	719	55
1915	596	27	115	38	776	81

Mr. George H. Finneran submitted the following report for the Auditing Committee:

REPORT OF AUDITING COMMITTEE.

BOSTON, MASS., January 11, 1916.

We have examined the accounts of the Secretary and Treasurer of the New England Water Works Association, and find the books correctly kept and the various expenditures of the past year supported by duly approved vouchers.

Respectfully submitted,

A. R. HATHAWAY,
BY G. H. F. AND A. L. S.,
ALBERT L. SAWYER,
GEORGE H. FINNERAN,
Auditing Committee.

On motion of Mr. George A. Stacy, it was voted that the foregoing reports of the officers and committees be accepted, placed on file, and printed in the JOURNAL.

The President then delivered the following address.

Some Observations upon the Control of Public Utility Companies by Public-Service Commissions.

Presidential Address delivered before the New England Water Works Association, January 12, 1916, by Leonard Metcalf.

During the past two years, the speaker has chanced to be engaged upon problems relating to the practical control of public utilities by public-service commissions and regulating boards, more particularly of certain water works, and to hear from many others of their experiences in this field of public activity. In view of the belief that the control of public utilities by public-service commissions, or like regulating boards, is probably the best solution of the present-day issues between the public and the corporation, it may perhaps be of interest to point out some of the good features and discuss some of the dangers that have developed or been indicated by practice in the past five to ten years, and the possible remedies for them.

GOOD FEATURES OF COMMISSION CONTROL.

The good features of commission control are so apparent as to require little comment. They have been realized in large measure, but in varying degrees in different places, depending upon the personnel and viewpoint of the commission, the facilities and funds available to it, the attitude of the corporation, and the past as well as present conditions and limitations surrounding the operation of the utilities. Briefly, they may be summed up under the following heads:

1. Wholesome publicity, — giving to the public the truth with regard to the operations of the utilities. This has served to lay bare the position and plans of the corporations and to prevent abuse of privilege. It has also served to bring home to the public in an authoritative and credible manner the difficulties under which the corporations sometimes operate.

2. Enforcing adequate service. In this respect the commissions have been of service in the case of over-capitalized properties, and have helped to prevent an intolerant attitude toward the public on the part of the corporation where such tendency existed. On the other hand, they have brought home to the public that extensions of service sometimes fail to yield fair return for some years after construction.

3. Establishing just rates. This is probably the most important and far-reaching service which the public utility commissions are performing to-day. The task is a very delicate one, involving not only tolerance and judicial spirit, but painstaking study of past conditions, breadth of experience, and knowledge concerning construction and operating conditions and costs.

4. Reducing the hazard and thus increasing the stability of investment by preventing an intolerant position on the part of the corporation or of the public, — thus enabling the corporation to borrow money for its necessary extensions at rates more advantageous alike to the corporation and public. A striking example of the greater stability of public utility securities resulting from commission control is to be found in the state of Wisconsin, as a result of the work of the Wisconsin Railroad Commission.

5. Curbing undesirable exploitation and preventing inflation of securities and estimated values, — thus helping to protect the innocent investor from loss growing out of his inability to thoroughly post himself concerning the real value of the securities offered by corporations.

Many examples might be cited to illustrate these and other less important good features of commission control, but the arguments are so well known and the object lessons have been so common as to make it unnecessary to detail them here.

DANGERS OF COMMISSION CONTROL.

Politics. The dangers of commission control are most often traceable to one source, — the intrusion of politics, — the bringing of political or corporate pressure to bear upon individuals where judicial considerations alone should govern; though the question of proper viewpoint for the commission, as to its relation to the public and to the utilities, and as to desirable limits of control, are important factors, — dependent as they are, not alone upon sound economics but the local psychological atmosphere created by the past relations, good, bad, or indifferent, between the public and the corporation.

The Lack of Experience in the construction and operation of public utilities — of some who have been appointed to the commissions, and more particularly of some of the engineering staffs appointed by them — has already resulted at times in litigation

and expense which would have been avoided had these men but had greater experience in the actual difficulties and hazards of construction and operation. The good motives of these men are not here questioned or at issue, but merely the injustice which may unwittingly be done by such, through lack of experience, and the ultimate cost resulting to the public.

Lack of Available Resources and Uncertain Tenure in Office. In this respect the commissions have been seriously hampered through lack of appropriations to command the services of men of mature judgment and breadth of experience in the operation as well as the design and construction of public utilities. Moreover, the uncertain tenure of office in such work has sometimes militated against the commissions and the public.

Burdensome Cost of Litigation. The lack of breadth of experience of men employed by the commissions in the valuation of public utility properties sometimes causes burdensome expense of litigation. This results from the fact that men of experience can arrive often at results, by methods of approximation growing out of the breadth of their knowledge and experience, which would be equitable, authoritative and acceptable and which would tend to limit the extent and cost of preparation of evidence by the corporations and the public for presentation before the commission, and subsequently before the Federal Court, to narrow limits, whereas, with lack of experience on the part of the commission or of its staff, the corporations and the representatives of the public feel it necessary to present evidence in far greater detail, coupled with comparative analyses of experiences had elsewhere, in the hope of making clear to the inexperienced reviewer the force of their claims. It is clear that, if appealed cases become numerous, the cost of the utilities' service to the public will necessarily be increased thereby, as experience in past trials of valuation and rating cases before the courts has demonstrated the burdensome character of the expense involved. Thus, in water-works valuation and rating cases, the joint expenses of trial to the parties at issue have often amounted to from ten to fifteen per cent. of the total value of the property, sometimes exceeding the higher amount in cases involving small plants, and being somewhat less than the lower in those involving the larger. Clearly, such expenses, though

often unavoidable, involve economic waste, as these funds could much better be applied to improving the property and character of the service than to paying the expenses of litigation, unless the latter serve to bring about a new and better era in the feelings toward one another of the parties at issue. Not only have courts, commissions, and arbitration boards recognized the burdensome character of this expense, but even the lawyers and experts called upon to assist in the conduct of these suits, and conscientious effort has generally been made by the latter to eliminate by agreement, in advance of the trial, as many of the issues at bar as possible, with a view to decreasing unnecessary expense. Often it happens in court trials that, while both parties may in good faith desire to bring about such agreement, the political situation may make it practically impossible to undertake it without running the danger of possibly having the subsequent decision called into question by reason of such joint effort. In these cases, the public utilities commissions are in a position to be of marked service to the parties at issue.

Innovations in Methods of Trial to Save Time and Expense. Some interesting and significant departures have been made from the ordinary legal methods of trial with a view to decreasing the expenses involved in such litigation. Thus, in the valuation of the water-works property of the Macon Gas, Light and Water Company, the board of seven arbitrators, consisting of five engineers and two bankers, outlined and adopted the following course of procedure in the interest of economy of time and expense. First, counsel opened with an historic sketch of the situation; second, the witnesses of the corporation and then of the city stated their qualifications, the nature and extent of their investigations, and their findings, briefly and without the intervention of counsel, either in direct or cross examination; third, counsel on both sides then discussed intangible or semi-intangible values, and, finally, any witnesses desired were recalled by the board at the request of counsel on either side, for cross-examination.

The program outlined proved acceptable to the parties at issue, and as a result of its adoption, the trial was concluded in a two weeks' period at a cost of about three per cent. of the amount of the award, instead of fifteen per cent. (more or less) which might

have resulted had the ordinary legal methods of procedure been followed.

Similarly, the procedure before some of the public utilities commissions is conducted on informal lines, instead of by categorical question and answer with explanation, and the witness is interrupted by the members of the commission at will in order to make clear, as they arise, any doubtful points and to bring home to the witness any considerations overlooked, which might influence his judgment.

More recently (1915) the Master in Chancery of the Federal Court of the District of California, Hon. H. M. Wright, in the trial of the Spring Valley Water Company rating cases at San Francisco, modified the ordinary order and methods of court procedure; first, by hearing all of the evidence upon real estate values before admitting evidence upon structural values; second, in hearing the evidence upon structural plant, by having all of the experts give their evidence, simply and in the form of a connected story unaided by counsel, upon a single group of property,— such, for instance, as earth dams, or pumps, or conduits,— and by permitting counsel to cross-examine the witnesses after the giving of this testimony and before taking up the next class of items. Incidentally, the experts upon the one side were at liberty to question the experts of the other and to assist the court by statements of their own experience, — in the nature of rebuttal, in reply to and as tending to meet the statements of the other experts. The plan has worked admirably, and the Master has already given expression to the opinion that the time consumed has probably not been over one third to one half as great as it would have been if the ordinary methods of court procedure had been followed. Furthermore, it is believed that the Master was thus put into the position to form judgment fairly conclusively upon the various phases of the case under trial, as the evidence was adduced and while the subject was still freshly in mind, instead of being obliged to carry an enormous mass of detail and review the previous testimony, as becomes necessary in ordinary methods of court procedure in important cases long under trial.

In a recent hearing before Judge Sessions at Grand Rapids, upon the suit of Ann Arbor *v.* State of Michigan, the court limited the

introduction of evidence and expenditure of time in the trial, by limiting the cross-examination practically to questions touching upon the qualifications of the witnesses, their honesty of purpose, the soundness of the theories advanced by them, and the major items (only) entering into the estimates of the engineers, — refusing to consider petty items as likely to have little effect upon the decision. The trial was concluded in six days, which is certainly a remarkably brief hearing for a case involving property values of ten million dollars, more or less. It is of significance, however, as indicating the viewpoint of the court upon methods of trial and the desirability of considering these problems upon broad lines, rather than in petty detail, which again brings into prominence the necessity for the review of such questions by men of breadth of experience in the construction and operation of such properties.

Another departure which has been suggested is to be found in the appointment, by the court, of a disinterested engineer of experience to aid it in the formation of sound judgment, in effect calling the engineer to sit upon the bench with the judge to pass upon technical matters and to aid in limiting the lines of investigation to matters of fundamental importance and weight.

The observations here made upon court trials apply in certain respects to trial by commission, and serve to accentuate the desirability of having competent engineers as well as lawyers and business men appointed to our public utilities commissions. The engineering, as well as the legal, point of view is of great importance in assisting to an expeditious and equitable solution of public utilities problems.

Dictation of Operating Policy v. *Simple Control.* The relative desirability of virtual dictation of operation policy, rather than simple control by the commission, and the determination of desirable limits of control, raise difficult and delicate questions which can only be settled in judicial spirit after careful study, open-minded discussion on both sides and, in some cases perhaps, actual trial. Obviously, control implies a certain amount of dictation. The question therefore resolves itself into one as to the extent of control which may prove most advantageous in the long run to the public interest. Equitably, the larger the measure of control exercised, the greater should be the financial responsibility of the

dictator. If our commissions are to dictate policies they will require greater opportunity, better facilities, and far greater financial support to form and exercise sound, far-sighted judgment. If they then dictate the policies to be pursued in management of the public utilities, the corporations should be relieved of the hazard incident to the enforcement of these policies. If, on the other hand, the corporations are still to be made to bear all responsibility and hazard, they should be given reasonable latitude in determining policies and the demands of future service, and should be accorded rates of return commensurate with the hazards involved in their business.

The Failure to Place Adequate Value upon Public Utility Properties, or to make proper allowance for appreciation in value; the elimination of portions of the property from the rating base, as not actively and immediately necessary to the service of the public; and the reduction of the rates to a point which will not produce a return fairly commensurate with the hazard of the business and in keeping with rates of return prevailing thereabout in other classes of enterprise, — all carry with them real dangers to the public, the character and ultimate result of which the public little realizes. Thus, if the difference in value between the mere assemblage of the structures and real estate, "the bare bones of the property," and the living, going concern, with established profitable business, — which it has involved time, effort and real cost to develop, — is not fully recognized; if spare machinery, reserve structures and reserve properties held for the service of the public or bought for use in the reasonably near future, are excluded from the rating base; or if the rate of return fails to provide reasonable depreciation allowance as well as fair return commensurate with actual hazard, — the final result is much the same. The commission may temporarily determine operation and values even to confiscation of a portion of the property value and cutting off of the market for the corporations' securities, but in the long run economic principles will control and the inevitable cycle will follow:

1st. Declining service resulting from failure to keep the property up, — just as the rentor of a farm may take, not only his profit out of the land but its actual ability to produce.

2d. Inadequate service, growing out of service standards neces-

sarily lowered for want of proper return, — just as the exhaustion of the soil of the farm results in lessened future crops.

3d. Inability to borrow new capital upon as advantageous terms, and more aggravated operating and service conditions than theretofore, — similar to the conditions prevailing when the soil of the farm is worked out.

4th. The disadvantages may go even to the actual inability to make good the errors of earlier operating policy, without largely increased cost. Thus in the semi-arid or arid regions, unless water rights are bought considerably in advance of the demands of the community, by the time they are actually needed they may acquire virtual monopoly prices growing out of their utilization for other purposes, and a totally different scheme of construction and operation may have to be followed at substantially greater expense than that which might have been followed had the necessary rights but been acquired at an earlier date. It is obvious, however, that, if earnings are to be denied for considerable periods of time upon such property, public utilities will not care to hazard their investments by having to carry them, without return, for long periods of time.

The public, or the commission, would find itself, therefore, under such conditions, face to face with the necessity of increasing the rating base or the permitted rate of return; with costly litigation; or with the necessity for embarking upon municipal or government ownership. A wiser course for the newly established public-service commission to pursue would seem to be that followed by the New Jersey Public Service Commission in the well-known Passaic Gas case, in which it endeavored to fully recognize values as of the date of its first value determination, and then defined the future method of accounting value and of determining or limiting the fair rate of return; thus giving to the owners of the property the opportunity to transfer their interest into other investments, if they were not content with the commission's future program.

Public Ownership Not the Goal. If public ownership is the real goal sought, a directer method of approach would effect a saving in the ultimate cost of acquisition of the desired properties. But various recent occurrences indicate that the general public is by no means prepared, as yet, to embark upon municipal or government ownership and operation of public utilities, generally or upon a large scale.

Rates. It is well recognized by intelligent managers that the public will more cheerfully pay liberal rates for adequate service than lower or even inadequate rates for bad service. Under normal operating conditions the rule is, " Look to your service first. Fair rates will follow," — though it is equally true that good service cannot long follow inadequate return.

THE REMEDIES.

Promising remedies for the dangers and abuses cited may be summed up as —

1. Non-political appointments and freedom from political or corporate pressure or control for the public-service commissions and their staffs.
2. Long tenure in office.
3. Higher salaries, — adequate to attract and hold men experienced in corporate affairs and in the construction and operation of public utilities.
4. As brief and direct methods as possible of establishing value and fair rate of return.
5. Reasonable regulation or control of the utilities by the commissions rather than dictation of operating policies.
6. Broad and fairly liberal treatment of the question of value and fair rate of return, particularly in the transition stage from no regulation to full control.
7. Support by the public of disinterested and sound findings in public-utility disputes made by competent tribunals, commissions, or men, — whether these findings bear heavily upon the corporation or fail to meet public expectation.

The positions upon the commissions and their staffs are no sinecures. They demand sturdy, fearless character, judicial spirit, and breadth of training and experience.

Let us not underestimate the difficulty of the task or belittle the work of the conscientious men now struggling with this important problem. There are many of them, and they deserve the thoughtful regard and frank support of this and other like organizations.

On the other hand, the dangers of the situation and the penalty involved in unfair standards, either upon the part of the public utility, the public which it serves, or the public-service commission

— which should stand in a strictly judicial position between the two — is not to be ignored.

The writer is conscious that in the foregoing illustrations he has perhaps over-emphasized the dangers to the corporation, as compared to the benefits to the public, to be attained by competent regulation of utilities by public-service commissions. This somewhat unbalanced presentation has followed in part as a result of some recent experiences, and in part because the direct advantage to the public of the commission's powers to curb the corporations is more evident. This latter function is so prominent that many people have a tendency to lose sight of the judicial or impartial stand which commissions should take, and to think of them mainly, if not solely, as agencies for reducing rates.

The true function of a public-service commission is to act as a referee, charged with seeing, on the one hand, that the public has to pay no more than a fair price for the service rendered, and that it receive service of the character for which it pays; and with seeing, on the other hand, that the utility receive fair treatment and compensation. The public, and the corporation as well, can derive benefit only from the regulation of utilities by an able and impartial commission.

This is equally a fact whether the utilities be owned by corporations or by the public themselves; and the writer would not be surprised to see the jurisdiction of the commissions more generally extended in the near future to cover matters relating to the accounting, financing, and making of rates of municipally owned utilities.

Mr. William A. Bradford, president of the South Shore Master Plumbers Association, Quincy, Mass., then presented a paper entitled, "Causes of Explosions of Domestic Boilers." The paper was illustrated by stereopticon views. On motion of Mr. Coggeshall, the thanks of the Association were extended to Mr. Bradford and he was invited to attend the February meeting, to which time the discussion of the paper was postponed.

Mr. Charles W. Sherman read a paper by C. W. Sherman, William S. Johnson, and Henry A. Symonds, on "Municipal

Water Works Financing in Massachusetts as Affected by Recent Legislation."

The subject was discussed by Mr. Charles F. Gettemy, director of the State Bureau of Statistics, and Mr. T. M. Waddell, chief of the Municipal Division of the Bureau.

On motion of Mr. Coggeshall, a vote of thanks was extended to these gentlemen for attending the meeting and expressing their views upon the subject under discussion.

Election of Officers.

Mr. Arthur E. Blackmer submitted the following report of the Tellers appointed to canvass ballots for officers for the ensuing year:

Whole number of ballots	364
Blank	3

President.

William F. Sullivan	346
Scattering	2

Vice-Presidents.

Caleb M. Saville	349
Carleton E. Davis	354
Samuel E. Killam	351
R. S. Lea	349
D. A. Heffernan	349
W. W. Brush	354
Scattering	2

Secretary.

Willard Kent	356

Treasurer.

Lewis M. Bancroft	356

Editor.

Richard K. Hale	355
Scattering	1

Advertising Agent.

GEORGE A. KING	359

Additional Members Executive Committee.

R. C. P. COGGESHALL	355
ROBERT J. THOMAS	355
FRANK J. GIFFORD	351
Scattering	1

Finance Committee.

GEORGE H. FINNERAN	350
D. N. TOWER	352
JOHN MAYO	352
Scattering	2

Respectfully submitted,

ARTHUR E. BLACKMER,
FRANK J. GIFFORD,
Tellers.

After announcing the names of the newly elected officers, the retiring President, Mr. Metcalf, said:

In yielding the gavel to my successor I want to express to all of you the pleasure which it has given me to serve you this year, in so far as it has been possible for me to do so, being, as I was, across the Continent the greater part of the time when I should have been in this part of the country. On the other hand, I can do no more for Mr. Sullivan than to bespeak for him the same sort of cordial support and assistance which I have had during my term of office. Mr. Sullivan, as you know, was from 1887 to 1906 in the Water Department at Lowell; then he went to Nashua to take up the work there of guiding the destinies of the Pennichuck Water Works. He was elected a member of this Association on St. Valentine's Day in 1900. He has contributed, as you well know, important papers and has taken a very active interest in the affairs of the Association, serving on many important committees. He came to you, gentlemen, as a Valentine gift; he comes to the presidency in leap year. The signs augur well for a successful administration. In presenting him to you I only want to call his attention to what he faces on the membership

proposition; but for his comfort let it be said that if your retiring president, though absent so much, has been able to witness the increase in membership which has taken place, there is no telling what our new president can do as a " Johnny-on-the-spot." Gentlemen, I present to you Mr. Sullivan. [*Applause.*]

PRESIDENT SULLIVAN. *Mr. President and Members of the New England Water Works Association,* — It is an honor, a great honor, to be elected President of this Association, and I fully appreciate it. I also realize the responsibilities. I share the honors and the responsibilities with the other officers who have been elected, and I feel safe in saying that the officers and the Executive Committee will work with one end in view, and that is for the continued success of this Association. To do this we need your support and your coöperation. We want you to maintain the popularity of these meetings; we want you to popularize all gatherings of the New England Water Works Association. To-day the outgoing administration turns over to the incoming administration an organization of almost one thousand members. Think of it, one thousand members! Could that little band of pioneers, away back in the early eighties — and I might say that it is a pleasure for us all to see some of those early members here to-day — could they have thought how well they builded? Could they have dreamed of such an organization as this? It is the earnest desire of the officers and myself that you continue the popularity of these meetings. We have these monthly gatherings, and it is a time when we may get together to meet and greet one another, rub elbows with one another, — as it were, — exchange ideas, discuss problems and listen to high-grade papers; and not the least of a member's privilege is that he may discuss the papers. For it is by means of a free discussion that our members will be able to get information not easily obtained in any other way.

With this splendid membership as a legacy, how are we to fill up the gaps occasioned by the natural losses in membership? How are we to obtain new members? We know there are many men in the water-works business and in the engineering profession who are not availing themselves of the benefits of this Association. How many members are there of your water boards, directors, commissioners, of your office, engineering and station forces, who

ought to be members, not only to swell the membership of this Association, but for their own benefit? They would profit by coming to these meetings and listening to the papers, and it goes without saying they would be the gainers by reading the JOURNAL.

The President says I was elected a member of this Association on St. Valentine's Day. I will take his word for that. There are different kinds of valentines. Years ago, about the time I was elected, the comic valentine was very much in evidence.

As for this being leap year, I am a hopeless case. I have been roped and tied for some time. The hour is getting late, and I am not going to make any extended remarks, but I would like to say this in reply to the retiring President's remark of my being "Johnny-on-the-Spot": I do not know whether there is anything in our constitution which provides for a recall, but let me tell you it will be just as severe a shock to me if I get a "call down" as to get a recall. So I am going to make the effort to have our membership reach the one thousand mark, and I ask you all to assist me. Let our slogan be, "One thousand members or more." Let us keep up the good work, begun so many years ago. Let us keep this organization where it always has been and where the retiring President leaves it to-day, in the very forefront of such associations.

Again thanking you for the honor which you have conferred upon me, I wish you all a Happy New Year and I bespeak for the officers and for myself that you make this a popular and prosperous year for the New England Water Works Association.

HOTEL BRUNSWICK,
BOSTON, February 9, 1916.

The February meeting of the Association was held at the Hotel Brunswick, Copley Square, Boston, Wednesday, February 9, 1916, President Sullivan presiding.

The following members and guests were present:

HONORARY MEMBERS.

E. C. Brooks, A. S. Glover, F. E. Hall, F. P. Stearns. — 4.

Members.

C. L. Baker, L. M. Bancroft, A. E. Blackmer, J. W. Blackmer, C. W. Bowker, J. C. Chase, H. W. Clark, R. L. Cochran, F. L. Cole, J. E. Conley, John Cullen, A. O. Doane, John Doyle, E. D. Eldredge, G. H. Finneran, F. F. Forbes, F. L. Fuller, Patrick Gear, F. J. Gifford, H. J. Goodale, R. K. Hale, A. R. Hathaway, T. G. Hazard, Jr., D. A. Heffernan, A. C. Howes, E. F. Hughes, J. L. Hyde, C. E. Johnson, W. S. Johnson, Willard Kent, G. A. King, Horace Kingman, J. L. Kirkpatrick, E. J. Looney, Hugh McLean, H. V. Macksey, A. E. Martin, W. E. Maybury, John Mayo, H. A. Miller, J. W. Murphy, William Naylor, H. G. Pillsbury, L. C. Robinson, H. W. Sanderson, C. M. Saville, A. R. Sawyer, M. R. Scharff, J. E. Sheldon, C. W. Sherman, E. C. Sherman, H. L. Sherman, H. M. Sinclair, J. W. Smith, Sidney Smith, W. F. Sullivan, C. N. Taylor, A. H. Tillson, D. N. Tower, C. H. Tuttle, W. H. Vaughn, R. S. Weston, J. C. Whitney, F. I. Winslow, I. S. Wood, L. C. Wright. — 66.

Associates.

Harold L. Bond Co., G. S. Hedge; Builders Iron Foundry, A. B. Coulters; Central Foundry Co., W. H. Feltt; Chapman Valve Mfg. Co., J. T. Mulgrew; Eddy Valve Co., H. W. Dotten; Hayes Machinery Co., F. H. Hayes; Hersey Mfg. Co., J. H. Smith, A. S. Glover, and W. A. Hersey; Lead Lined Iron Pipe Co., T. E. Dwyer; Ludlow Valve Mfg. Co., A. R. Taylor; H. Mueller Mfg. Co., G. A. Caldwell; National Meter Co., H. L. Weston and J. G. Lufkin; Neptune Meter Co., H. H. Kinsey; Pittsburgh Meter Co., J. N. Turner; Rensselaer Valve Co., C. L. Brown; A. P. Smith Mfg. Co., F. L. Northrup; Standard Cast Iron Pipe and Foundry Co., W. F. Woodburn; Thomson Meter Co., E. M. Shedd; Union Water Meter Co., F. E. Hall; Water Works Equipment Co., W. H. Van Winkle; R. D. Wood & Co., H. M. Simons; Henry R. Worthington, E. P. Howard and Samuel Harrison; Warren Foundry & Machine Co., J. H. Morrison. — 27.

Guests.

J. H. Fields, Jr., Nashua, N. H.; D. H. Henderson, Cambridge, Mass.; H. G. Porter, H. W. Coombs, O. Z. E. Charest, H. W. Storrs, Boston, Mass.—6.

The Secretary presented the following applications for membership, properly endorsed and recommended by the Executive Committee:

Resident: Arthur W. Beckford, Danvers, Mass., water commissioner; Charles W. Bowker, South Paris, Me., superintendent and chief engineer; J. Frank Ellis, Rochester, N. H., water and sewer construction; George H. Leland, Providence, R. I., waterworks design and construction; Fred H. White, South Easton, Mass., water commissioner and superintendent.

Non-resident: Walo von Greyerz, Stockholm, Sweden, chief engineer; A. P. Learned, Kansas City, Mo., civil engineer; Maurice R. Scharff, Pittsburgh, Pa., general sanitary and hydraulic engineering practice.

Associate: Warren Foundry and Machine Company, 11 Broadway, N. Y., cast-iron pipe and fittings.

On motion duly made, the Secretary was directed to cast the ballot of the Association in favor of the applicants, and he having done so they were declared duly elected members of the Association.

The Secretary read the following recommendation from the Executive Committee:

"FEBRUARY 7, 1916.

"A grading scale for cities and towns has very recently been proposed by the committee on fire protection of the National Board of Fire Underwriters. With a view to safeguarding the interests of city water-works departments and private water-works owners, it seems very desirable that some action should be taken by this Association to approach this matter from the standpoint of the utility. In order to bring this matter before the Association the Executive Committee of this Association recommend that a committee of five be appointed by the chair to confer with the engineers of the National Board of Fire Underwriters before the standard grading schedule is finally adopted."

MR. CHARLES W. SHERMAN. Mr. President, I have been fortunate enough to secure from the National Board of Underwriters a copy of their proposed schedule. In order that the members may understand what we are talking about, perhaps I would better elaborate a little. For quite a number of years some of us have been trying from time to time to find out from the underwriters what changes in insurance rates would result from the construction or improvement of water-works systems, and we have never been able to get very much satisfaction out of it. Now the National Board of Underwriters have started to prepare a standard grading system, on the basis of which they will fix a certain standard for what they consider perfect protection, and take off a certain number of points for deficiency in certain lines. That applies not only to water works, but to fire departments, police, and the rest; but the water-works part of it interests

us very much. I prepared this vote before hearing that the Executive Committee were interested. I move

"That the President be authorized to appoint a committee of five members, to be known as the Committee on Grading Water Works for Fire Protection, who shall consider the 'Proposed Standard Schedule for Grading Cities and Towns of the United States with Reference to their Fire Defenses and Physical Conditions,' and report to a future meeting of the Association whether or not it is desirable for the Association to endorse this or any similar schedule. The committee shall have authority to confer with the National Board of Fire Underwriters or its engineers or other representatives, and with any similar committee from the American Water Works Association, or any other body of water-works engineers, and may, if in its judgment it is wise to do so, render its report as a joint report with such other similar committees."

[The motion was duly seconded.]

MR. SAVILLE. I think there are two committees or associations that are interested in this classification. These are the New England Insurance Exchange, which, as I understand it, covers old line companies, and the Factory Mutual Bureau, which confines itself to a limited class of risks. I don't know whether the New England Mutual goes outside of New England or not, but I understand that the National Board of Underwriters covers the whole country. I think that any action that the Association would take should not be antagonistic to the local insurance bureaus, but rather endeavor to bring about harmony between the water-works interest on the one hand and the insurance interest on the other.

MR. SHERMAN. My personal correspondence has been with the National Board, or rather its chief engineer, Mr. Booth, and it is through him that I succeeded in getting a copy of the schedule that is prepared by the National Board.

MR. FULLER. I would like to know if the rates are not fixed by the local boards. I don't know what the National Board would have to do with fixing rates in New England.

MR. SAVILLE. I am not familiar with this except in a local way, but I do know the National Board of Underwriters have been active all through the country — in the larger cities, anyway — and have been trying out and testing water-works systems. I

presume they are intending to make up this schedule on the basis of their investigation.

MR. H. V. MACKSEY. If we are to appoint a committee to confer with the National Association of Fire Underwriters I would like to know upon what terms we are to go into the conference. Do we go on terms of equality? Do they want us? Are they going to ask our advice and accept our judgment? My limited experience, and that of some of my friends, has been that the fire underwriters undertake to tell those who buy fire insurance from them what they shall do and what they shall pay for it. They also undertake to pass judgment on various water departments and say what value they put on them without outside aid or assistance. It is a matter that affects their profits and the cost to the person who is buying the underwriting, and if we as representatives of water works and minor officials in cities go into conference and try to tell them what they shall do and how they shall rate various cities and various properties, I think they will give us short consideration. I do not see any reason why our name should be tacked on and why we should be a tail to their kite. If they want our advice and will accept our suggestions, if our vote will have any weight or authority with them, then we would have license to go into conference, but suppose a committee consisting of water-works superintendents were to consent to the rating of cities, and their own cities should be rated low against their protest, well — there would be no brass band out to meet them when they arrived home.

MR. SHERMAN. This committee will be given power, according to this motion, if in its investigation it is thought wise, to confer with the National Board or with other committees. They are to report back to this Association, of course, and they are to report to us whether or not they think it is wise to endorse that or any similar schedule. I think the wording is safe.

[The motion was adopted.]

The President subsequently appointed the following committee: F. A. McInnes, C. M. Saville, H. V. Macksey, C. W. Sherman, and R. J. Thomas.

MR. SAVILLE. To bring another matter before the Association, I would like to move that the vote passed by the Executive Com-

mittee that the initiation fees be remitted to members and associates of the American Water Works Association applying for admission to the New England Water Works Association during the year 1916 be approved by this Association. That, I understand, is about the same motion that was made last year.

[The motion was seconded.]

PRESIDENT SULLIVAN. You have heard the motion. Is there anything to be said on it? It is extending the courtesy that has been granted by the American Water Works Association to the members of the New England Water Works Association. We are going to continue to give the members of the American Water Works Association who have not availed themselves of it the opportunity to join.

[The motion was adopted.]

MR. SHERMAN. Mr. President, I would like to take just a minute to make what may be called a progress report for the Committee on the Dexter Brackett Memorial. Contributions are coming in in good shape. The committee is now considering in a general way what shall be done about the design of a medal, and while they have not yet selected a designer, they are perhaps approaching the point of doing so. I have here to-day a sample medal that was prepared for the National Academy of Science, that is similar to the one we have in mind; also photographs of two or three other medals. I should be glad to show them after the meeting to any that are interested.

THE SECRETARY. The following letter from Mr. Edward C. Sherman was presented to the Executive Committee, and its recommendations met with their approval and it was voted that it be presented at this meeting of the Association.

JANUARY 31, 1916.

Dear Sir, — A few engineers who are interested in the welfare of the city of Boston and who consider the recent action of Mayor Curley in making wholesale removals in the Public Works Department to be a detriment to the city and a blow to the engineering profession, wish to raise funds to be used in presenting the cases of F. A. McInnes, Storrs L. Durkee, and Bliss W. Robinson before the courts to which they have been appealed following an unsatisfactory hearing before the Commissioner of Public Works.

The Good Government Association will bear the greater part of the expense, but an additional amount, estimated at from $300 to $600, will be needed.

If you desire to contribute to the funds, please notify me of the maximum amount which you would care to give. Then when it is known how much will be required, you will be assessed in the proportion which your maximum offer bears to the total amount subscribed. Do not send any money now.

A prompt reply will be appreciated so that we may know how much we may count upon. It will be considered confidential.

Yours very truly,

EDWARD C. SHERMAN.

PRESIDENT SULLIVAN. The communication is self-explanatory.

A paper by Robert B. Morse, chief engineer, Department of Health, Baltimore, Md., on "Progress of Water Sterilization in Maryland," was read, in Mr. Morse's absence, by Mr. Saville. The paper was discussed by Mr. Harry W. Clark, of Boston.

The Association then listened with much enjoyment to some songs by Mr. James E. Donnelly, of Lowell, Mr. Bradford having responded to an appeal for an accompanist.

The Association then took up the discussion of causes of explosions of domestic boilers, the discussion being opened by Mr. D. A. Heffernan, of Milton.

Mr. W. A. Bradford gave a demonstration of the operation of safety valves, and also discussed two bills introduced by him into the General Court.

The following gentlemen participated in the discussion: Mr. F. F. Forbes, of Brookline; Mr. Caldwell; Mr. Frank L. Fuller, of Boston; Mr. Edward D. Eldredge, of Onset, and others.

The remainder of the meeting was occupied with a discussion of the report of the Committee on Meter Rates.

EXECUTIVE COMMITTEE.

Meeting of the Executive Committee of the New England Water Works Association at headquarters, Tremont Temple, Boston, Mass., January 12, 1916.

Present: President Leonard Metcalf; James Burnie, Chas. W. Sherman, Caleb M. Saville, Wm. F. Sullivan, Edwin C. Brooks, Samuel E. Killam, Lewis M. Bancroft, Willard Kent.

Ten applications for membership in the Association were received and the several applicants were by unanimous vote recommended therefor, viz.:

Members: William G. Newhall, assistant superintendent Portland Water District, Portland, Me.; Raymond Walker, superintendent Water Company, Edgartown, Mass.; John P. Wentworth, assistant engineer, Metcalf & Eddy, Malden, Mass.; Joseph F. Ranger, Water Commissioner, Holyoke, Mass.; Fred B. Nelson, civil and hydraulic engineer, New York City, N. Y.; Edward G. Gushee, 2d assistant engineer, Bureau of Water, Philadelphia, Pa.; E. D. Bistline, secretary Water Company, Newport, Pa.; Edward Mayo Tolman, chief engineer State Department of Health, Charleston, W. Va.; James A. Steele, Jr., manager City Water Works, Vicksburg, Miss.; George Mitchell, water engineer office, Aberdeen, Scotland.

The question of advisability of action of the Association in the matter of appointing a committee on legislation was discussed, and Mr. Henry A. Symonds, present by invitation, expressed his views on the subject. On motion of Mr. Brooks, the matter was referred to the Executive Committee for the coming year.

The President presented the efficient report of Mr. Alfred D. Flinn, delegate of this Association to the Pan-American Congress, which was read and ordered placed on file.

President Metcalf presented a résumé of the work of the Association during the past year, and it was by unanimous vote adopted

as the report of the Executive Committee, to be presented at the meeting of the Association this day.

Adjourned.

WILLARD KENT, *Secretary.*

Meeting of the Executive Committee of the New England Water Works Association at headquarters, Tremont Temple, Wednesday, February 9, 1916, at 10.30 A.M.

Present: President William F. Sullivan, and members Caleb M. Saville, Samuel E. Killam, D. A. Heffernan, F. J. Gifford, Richard K. Hale, Lewis M. Bancroft, George A. King, and Willard Kent.

Voted, that the initiation fees be remitted to members and associates of the American Water Works Association applying for admission to the New England Water Works Association during the year 1916.

Voted, that the President appoint a committee on membership, to consist of the President, *ex officio*, and such other members of the Association as he desires.

Voted, on motion of Mr. King, that letter of Mr. E. C. Sherman, relative to discharge of engineers by mayor of Boston, be read at the meeting of Association this day.

Nine applications were received, eight for active and one for Associate membership as follows:

Charles W. Bowker, superintendent Village Corporation Water Works, South Paris, Me.; J. Frank Ellis, superintendent Water Works, Rochester, N. H.; Arthur W. Beckford, water commissioner, Danvers, Mass.; George H. Leland, Providence, R. I.; Fred H. White, superintendent South Easton and Eastondale Fire and Water District, So. Easton, Mass.; Walo von Greyerz, Stockholm, Sweden; A. P. Learned, engineer, Kansas City, Mo.; Maurice R. Scharff, engineer, Pittsburgh, Pa. Associate: Warren Foundry and Machine Company, New York, N. Y.; and they were by unanimous vote recommended therefor.

On motion of Mr. King, the Secretary was instructed to make

inquiry in regard to Albany, N. Y., as a place for holding the next annual convention.

On motion of Mr. Saville, the President was authorized to appoint a committee to confer with a Committee of the National Board of Fire Underwriters on proposed grading scale of insurance rates.

The certificate of renewal of Treasurer's bond for five thousand dollars, by the Massachusetts Bonding and Insurance Company, was presented and by vote approved.

Adjourned.

WILLARD KENT, *Secretary.*

Annual Convention to be held in Portland, Maine.
September 13, 14 and 15, 1916.

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OFFICERS

OF THE

New England Water Works Association

1916.

PRESIDENT.

WILLIAM F. SULLIVAN, Engr. and Supt., Pennichuck Water Works, Nashua, N. H.

VICE-PRESIDENTS.

CALEB M. SAVILLE, Chief Engr., Bd. Water Commissioners, Hartford, Conn.
CARLETON E. DAVIS, Chief, Bureau of Water, Philadelphia, Pa.
SAMUEL E. KILLAM, Supt. Pipe Lines and Reservoirs, Metropolitan Water Works, Boston, Mass.
R. S. LEA, Civil and Hydraulic Engineer, Montreal, Canada.
D. A. HEFFERNAN, Supt. Water Works, Milton, Mass.
WILLIAM W. BRUSH, Deputy Chief Engr., Bureau of Water Supply, New York, N. Y.

SECRETARY.

WILLARD KENT, Civil Engineer, Narragansett Pier, R. I.

EDITOR.

RICHARD K. HALE, Civil Engineer, 85 Water Street, Boston, Mass.

TREASURER.

LEWIS M. BANCROFT, Supt. Water Works, Reading, Mass.

ADVERTISING AGENT.

GEORGE A. KING, Supt. Water Works, Taunton, Mass.

ADDITIONAL MEMBERS OF EXECUTIVE COMMITTEE.

R. C. P. COGGESHALL, Supt. Water Works, New Bedford, Mass.
ROBERT I. THOMAS, Supt. Water Works, Lowell, Mass.
F. J. GIFFORD, Supt. Water Works, Dedham, Mass.

FINANCE COMMITTEE.

GEORGE H. FINNERAN, Asst. Supt. Water Service, Boston, Mass.
D. N. TOWER, Supt. Water Co., Cohasset, Mass.
JOHN MAYO, Supt. Water Works, Bridgewater, Mass.

THE ASSOCIATION was organized in Boston, Mass., on June 21, 1882, with the object of providing its members with means of social intercourse and for the exchange of knowledge pertaining to the construction and management of water works. From an original membership of only TWENTY-SEVEN, its growth has prospered until now it includes the names of over **900** men. Its membership is divided into two principal classes, viz.: MEMBERS and ASSOCIATES. Members are divided into two classes, viz.: RESIDENT and NON-RESIDENT, — the former comprising those residing within the limits of New England, while the latter class includes those residing elsewhere. The INITIATION fee for the former class is FIVE dollars; for the latter, THREE dollars. The annual dues for both classes of Active membership are THREE dollars. Associate membership is open to firms or agents of firms engaged in dealing in water-works supplies. The initiation fee for Associate membership is TEN dollars, and the annual dues FIFTEEN dollars. This Association has six regular meetings each year, all of which, except the annual convention in September, are held in Boston.

New England Water Works Association.
ORGANIZED 1882.

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This Association, as a body, is not responsible for the statements or opinions of any of its members.

WATER SUPPLY SANITATION IN THE NINETEENTH CENTURY AND IN THE TWENTIETH.

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Fellow-Members of the New England Water Works Association, — It is always a pleasure to come back to this room and to meet this company. It is also a great personal pleasure to reflect that I was at one time for one year your president, thanks to your kindness, and that I am one of your honorary members.

Fifteen years ago, or very nearly so, I read before the Association a paper on the "Rise and Progress of Water Supply Sanitation in the Nineteenth Century."* The reason for that was that we were then just ending the nineteenth century and people all over the world were bringing together the results of what was well called "The Wonderful Century." They were telling of the progress that had been made in art and in various sciences and in politics, in government, and all sorts of things, and it seemed to me right and proper that this Association, representing a great art and a great science in New England, and well known all over the world, should likewise stop and see what had been done during the nineteenth century for water supply sanitation. I prepared the paper with a good deal of care, and on looking it over lately, as I had not done for the nearly fifteen years that have gone by, I

* JOURNAL N. E. W. W. A.

am very much pleased, and not a little surprised, to find that what I said at that time I still believe to be entirely true. I have not found any statements that need to be made over.

The upshot of that paper was that in the nineteenth century it was discovered for the first time in the history of man that drinking water may convey disease. Up to the nineteenth century, people had supposed, many of them, that disease came as an act of divine Providence, or that it came as a punishment for sin, or that it came from meteoric disturbances, or from earthquakes or other strange things, and it was not until the middle of the century that we even discovered clearly that water could carry lead poison. That was the first discovery. And then we discovered that it could carry the germs of infectious disease. A great epidemic of Asiatic cholera in London, known as that of the Broad Street Well, happened in 1854. I was born in 1855, as I may mention in order that you may see that my life covers practically the whole period of our knowledge of water supply sanitation. It really covers a good deal more than that because we didn't get much sanitation until long after this memorable epidemic. In that famous outbreak six hundred people died — died, mind you, not sickened, from drinking the water of one well. And of course that fact taught a lesson to the world which it has never since forgotten. The details of that epidemic and other epidemics are given in the paper to which I have already referred and which I do not propose now to more than mention. That was in 1854. But although anybody looking over the evidence now is convinced immediately that it was the water of the well that did the work, medical men at the time — and they were the only men who seemed much interested — for the most part disbelieved the water theory; and although this was as plain a case as any one could wish, the best heads in London among the medical men, with one exception, came to the conclusion that after all the evidence was unsatisfactory and conflicting, and that it was not at all clear that the well had caused this fearful epidemic. Some said it was due to the fact that a number of years before a lot of dead bodies from Asiatic cholera victims had been buried in a field not very far off. Others came forward, no doubt, with the usual explanation of some meteor, comet, or earthquake, and most of them probably thought it an

"inevitable infliction of divine Providence." Dr. John Snow, however, a thoroughly scientific medical man, and Mr. Whitehead, a surveyor, worked the thing up very clearly, and any man who approaches the matter to-day unprejudiced cannot help being convinced immediately by all their data.

Now that was in 1854 and 1855. In 1866 there was another big epidemic of cholera traced to one of the London water supplies. In 1872 there was an epidemic of typhoid fever in Switzerland which set back all our sanitation in the nineteenth century, because the pollution in that case came through a hill to some springs in a little town named Lausen, and it seemed to people inconceivable that any infection could have been carried through a complete hill, a long hill. We now believe that there must have been a fissure or a channel through there; in fact, there was evidence at the time that there was. But people were more impressed by the evidence against that cause of the epidemic than they were by the evidence in favor of it. I remember that my distinguished predecessor and friend, William Ripley Nichols, for example, was always very skeptical about that particular epidemic. He didn't know anything about epidemiology — nobody did in those days, or hardly anything — and he had a right to be critical, particularly as his example in all these matters was important. Professor Pettenkofer of Munich was particularly cynical, critical, and sarcastic about it. Nevertheless, the truth undoubtedly was that typhoid fever germs had come through the hill, and to-day nobody disbelieves it who reads the evidence. That was in 1872.

In 1879, by which time I was just graduating from a scientific school, there was a typhoid epidemic traced to the pollution of a well which was being dug to add water to a small supply of a suburb of London, and the case there was so clear — when it was found that one of the workmen who had been digging in the well evidently had typhoid fever and had defecated in the well, so that the people had got his dejections pretty straight in the water — that the world began to see that water, after all, could carry the germs of disease.

In 1885 we had our greatest American lesson at Plymouth, Pa., when, out of 8 000 people, 1 200 came down with typhoid fever. That was not the worst epidemic of typhoid that we have ever

had, but it was the worst one that I know of due to water. Twelve hundred came down with typhoid out of a small population of 8 000. And it was absolutely proved in that case, to the satisfaction of everybody, that excreta from typhoid patients, thrown out on a little tributary of some small reservoirs supplying a part of the town, had been responsible for the epidemic.

Then came the Lowell and Lawrence epidemic of 1890, which many of those present will remember very well and which I personally had the opportunity to investigate. And after that there was no longer any doubt — and really even before this — that water could convey the germs of disease. But to show you how long we were in reaching this conclusion, and how slow the development of water supply sanitation was, even in the latter part of the nineteenth century, we have only to refer to the fact that one of the most distinguished engineers of the time, Mr. Cheesebrough, after a careful consideration of the conditions of the Merrimack River, reported in 1872 to Lowell and Lawrence that the best thing they could do to get a pure supply was to stick a pipe right down into that polluted river and pump the water to the people without any hesitation; "for it is clear," he said in substance, "from the examination of chemists, that running water purifies itself, and even the nine miles above the Lawrence intake are sufficient to render the water pure and safe." He did the same thing for Chicago and the same for Pittsburg, recommending them likewise to take highly polluted supplies, trusting, as he had a right to do, to the teachings of the chemists that running water purifies itself. But by the end of the century — for in the meantime had come the great typhoid and cholera epidemics in Hamburg in and before 1892 — by the end of the century, when I prepared this paper, it had become perfectly clear that running water does not adequately purify itself; and I am rather proud of the paragraph in my paper in which an idea is contained which had never been stated in quite the same way before, — although it is now well understood. The paragraph is headed, "Quiet water, not running water, purifies itself." And I remember the almost horror-stricken faces of some members of the Association when I read this paragraph, fifteen years ago. I will read it:

"The reason for this practice, now so thoroughly discredited"—

That is, the practice I had referred to in the previous paragraph, of taking water, as it had been taken at Lowell and Lawrence and Chicago and Pittsburg and Burlington, Vt., and many other places, —

"The reason for this practice, now so thoroughly discredited, was, as is well known, an undue reliance upon the so-called 'self-purification of streams,' a process which, though often real, is often also incomplete and untrustworthy. The idea prevalent in the greater part of the century that 'running water purifies itself,' while true enough up to a certain point and especially true so far as purification by dilution and by the displacement of dissolved gases is concerned, has in the last years of the century been shown to be either erroneous or to have little or no meaning so far as the direct oxidation of organic matter or the destruction of many living microbes which may be present in suspension, are concerned. For these latter, on the contrary, it would probably be more correct to say that 'quiet water purifies itself,' " —

I now often use the term "standing" water, — "stagnant" water, — for to stagnate means to stand,

— "since in such water microbes tend eventually to disappear, either dying from old age or inanition or settling to the bottom and being there detained."

That paragraph created a good deal of surprise at the time and also when it was published in my book on "Sanitary Science and Public Health." But it is absolutely true. It was true then and it is even truer to-day. We know better why this is so to-day than we did then. After summarizing things very much as I have done just now, I went on to speak of the influence of bacteriology upon the theory of filtration. I gave the history of filtration and the influence of bacteriology upon it, and I referred at the very end to experimental studies on filtration:

"Its theory and practice have been carefully studied, — perhaps more carefully at the Lawrence Experiment Station of the Massachusetts State Board of Health than anywhere else, — and its applicability to various kinds of water under various conditions has received elaborate and extended investigation, especially at Louisville, Ky., and Cincinnati, Ohio, under the direction of Mr. George W. Fuller, and at Pittsburg, Pa., by Mr. Allen Hazen. Under the advice and direction of Mr. Hazen, the city

of Albany, N. Y., in 1899 constructed a municipal filter of the most modern type for the purification of the polluted Hudson River which, unfiltered, had long been at once the source of water supply in Albany and the cause of an excess of typhoid fever. This filter has already demonstrated its sanitary efficiency and will probably stand in the future as a representative example of the best practical achievement of the century in the purification of a polluted water supply by slow sand filtration."

Then came a paragraph about the purification of water supplies against pollution at the source. With the experience of that suburb of London (Caterham) to which I have referred above, and of Pennsylvania (Plymouth) and of the Lowell and Lawrence epidemic, it required no great perspicacity to see that protection at the source is important. I then summarized the whole matter for the nineteenth century in a final paragraph, part of which I will read:

"PRESENT STATE OF THE SUBJECT."

"The nineteenth century has thus witnessed the gradual rise of modern water-supply sanitation, and considerable progress in its various branches. It is now agreed on all sides that impure water may be not merely a predisposing cause," —

as was alleged by many people, especially in the days of the Broad Street well. The wiseacre doctors said, "Well, possibly that well was a predisposing cause, but to think that it was the real cause is impossible,"

— "but the actual vehicle, of infectious diseases such as Asiatic cholera and typhoid fever. The 'ground-water' theory and the 'pathogenic' theory of typhoid fever have disappeared and the 'germ' theory is the only one recognized to-day."

That ground-water theory had a long and wide acceptance under the influence of Pettenkofer; and my friend Professor Nichols always shook his head when we mentioned the drinking-water theory of typhoid fever. One theory was known in Germany as the *Grundwasser Theorie* and the other as the *Drinkwasser Theorie.* Pettenkofer was in favor of the ground-water theory and Koch and his school were in favor of the drink-water theory.

"Filtration through sand, proposed in 1828, begun in London in 1829, and required by law for river-waters in London after 1855,

was at first slowly and empirically improved as an art, though its existence and sanitary value were repeatedly justified, especially in the cholera epidemic of 1866. It nevertheless passed under a cloud for a time, chiefly because of the phenomena of the Lausen epidemic of 1872, which seemed to show that even the most extensive filtration of an infected water supply was insufficient to remove the poison of the disease; and was only restored to its proper place in the confidence of experts after the lapse of time, the gradual accumulation of evidence in its favor, the powerful support of bacteriology, and especially after fresh and indubitable demonstrations of its efficiency and value, such as those afforded by the long experience of London, that of Altona in 1892" —

a suburb of Hamburg which did not get cholera, while Hamburg did, although the Altona raw water was worse, Altona having filters and Hamburg not having them, —

— "and that of Lawrence in 1893, etc.

"The nineteenth century has also witnessed great progress in the general recognition of the absolute necessity of carefully protected watersheds, not only for the collection of surface waters which are to be used without filtration, but also for those — such as the water of the Thames — which are to be both settled and filtered before their consumption. It has learned to recognize the fact that the so-called purification of polluted waters by 'running' in rivers, and even by 'storage' in small reservoirs, is often incomplete and untrustworthy, and recognition of this fact has led to great and enormously expensive undertakings such as the Metropolitan Water Works of Massachusetts and the Sanitary Drainage Canal of Chicago, both designed to secure not merely more abundant, but also purer, water supplies."

That, then, was the state of affairs at the end of the nineteenth century, or substantially that. Some of those present will perhaps say that too much emphasis was laid in that last paragraph upon the importance of protection at the source, of the sanitary control of watersheds and the like, and there is possibly something to be said on that head.

Now, what are the broader features of water-supply sanitation in the first decade and a half of the twentieth century?

In the first place, I think we may say that there has been no abatement in our requirements for sanitation. Disease-producing,

pathogenic, or infected water is even less tolerable to-day than it was then. These requirements — that is, the requirements for water-supply sanitation — were really mapped out and completed by the end of the nineteenth century, but our sanitary standards of to-day are higher than ever before.

In the second place, we have also raised our standards of prevention of infection. We consider prevention, sanitary collection, watershed purchase and control, and sanitary policing, of fundamental importance. But we have also learned that with the increase of population, especially suburban population, watershed ownership and control are becoming, and are likely to become, increasingly difficult.

In the third place, our faith in the great natural as opposed to artificial agencies of purification, filtration and storage, remains not only unabated but has been strengthened during the fifteen years under consideration. We believe to-day, even more than we did then, that quiet water rather than running water purifies itself, and great cities are depending on great storage basins for purification of their supplies, — and rightly so.

The Lawrence filter, the first in America to stand between a water both highly polluted and highly infected and a large industrial population, has now done its work faithfully for twenty-two years, and it has been successfully imitated by a host of followers. Storage, also, in the Wachusett Reservoir for the Metropolitan District of Massachusetts, and for many other great populations elsewhere, has abundantly proved its potency for sanitation.

On the other hand, we have not merely held fast to that which is good, but have also made brilliant advances. Progress, however, has taken the form not so much of prevention of pollution and infection as of cure by chemical treatment, of which chemical disinfection or sterilization by bleaching powder or liquid chlorine is undoubtedly the most important. Upon this I do not need to dwell. Supplies which are hardly deemed worthy of expensive filtration have been made safe by chemical disinfection. And we must understand that this is often differential chemical disinfection. That is to say, a disinfectant may be used of such a strength as to destroy germs present in the water, but not of a strength sufficient to destroy the people using the water. There is

differential treatment here just as there is in the administration of quinine for malaria. Quinine in sufficiently big doses is undoubtedly a poison, but quinine administered medically against malaria is what is called in medicine a specific, while in another sense it is a differential disinfectant.

Our other improvements have to do rather with the *refining* than with the sanitation of water supplies, and I may enumerate them as follows:

TWENTIETH CENTURY WATER-REFINING.

(*a*) *Final Sanitation*, by differential disinfection, etc.
(*b*) *Clarification*, by coagulation and sedimentation.
(*c*) *Differential Toxination*, by copper sulphate.
(*d*) *Decolorization*, by light and by coagulants.
(*e*) *Deodorization*, by aëration, etc.
(*f*) *Softening*.
(*g*) *Deferrization*.

I think we may see, in looking over the whole field and in comparing the twentieth century with the nineteenth, that our work in the twentieth century thus far has been largely, though not wholly, the *refining* of water. It is, of course, true that we have secured a very important new weapon in chemical disinfection, — an important sanitary weapon; but it is no less true that we have got a lot of improvements in the character of our waters which may well be called water refining, and which are of value quite apart from disinfection purposes or sanitary purposes, and these are, first, as stated above, *Clarification* by chemical coagulation, — that is to say, by the removal of turbidity and the carrying down of mud and the freeing of water from disagreeable appearance. Any one who remembers how the water was in Washington before it was filtered and as it is now after coagulation, or who remembers how it was in St. Louis before filters and coagulants were applied, knows very well what I mean.

Again, we have what I am calling *differential toxination*. I might call it intoxication or poisoning, but it is preferable to use some term that the public won't misunderstand, or won't understand at all, perhaps, and so I propose the term "differential toxination." It is the same idea, of course, as in chemical steri-

lization. By copper sulphate it is possible, as you know, to control troublesome algal growths by a process of chemical treatment which is practically intoxication and which is so arranged, so graduated, as to be differential. It will kill the growths but it won't injure the people who drink the water.

The next item which has come into great prominence in these fifteen years is *decolorization*. I very much wish, as I have often said to him, that Mr. Coggeshall would bring here and keep for us as a kind of perpetual show some of the old New Bedford water supply, which was as dark in color as dark tea. People were fairly content at one time with water as highly colored as that was and for most of the nineteenth century, but to-day decolorization has a distinct cash value with the public. And this whole matter of water supply treatment is becoming a refinement similar to that which leads us to prefer granulated sugar to the good old brown sugar with the molasses in it, which we had when we were youngsters, and which we still get sometimes, and which is very good, just as that old New Bedford water was most excellent though unattractive to look at.

Then, too, *deodorization* has come to have its value. There was a time — and it was not so far back in the nineteenth century, either — when water-works men did not take particular pains to deodorize water. They said, "The water is harmless and if you don't like the taste you must grin and bear it, or wait until the bad taste has passed by." But to-day tastes and odors — for most tastes are odors — are deemed well worth the closest attention of water-works officials.

Softening, too, has come in, beginning at Oberlin and Winnipeg, and a few other places, and has become one of the great things of the times; while one of the latest, as you know, is the treatment for iron, to get rid of excessive iron, *de-ferrization*.

Now, along with these, which I feel justified in calling refinements or processes of water refining, rather than processes of sanitation, we have had many interesting experiences. One of the most remarkable, I think, when the history of the time comes to be written, will be found to be that regarding the use of alum. In many cities there was no objection to the use of alum as a coagulant, but in some places there was very serious objection, — one

of the worst, probably, being Washington, or the District of Columbia, where the medical profession arose almost as one man and announced that it would not have alum used for the purification of the Washington water supply. The newspapers said that the people did not want "puckered" water; they didn't want "puckered" stomachs; and all sorts of devices were used to try to influence the people against the use of alum. They were assured that there was next to none in the water, but it didn't make any difference. And even intelligent medical men rose up and made a terrible powwow about the whole affair in medical meetings and delayed the proper purification of the Washington water supply for a number of years. Their attitude was very much like that of Liebig with reference to the microscope. Liebig, one of the most distinguished chemists of the nineteenth century, refused to look through a microscope, refused to believe that yeast was a living thing, refused to believe that you could learn anything by the use of a microscope, cast ridicule upon young men trying to follow in the footsteps of Helmholtz and Pasteur, and by his influence delayed the development of the germ theory for many years. A similarly unfortunate attitude was assumed by the medical profession in New York City at one time in respect to pasteurized milk. The behavior of the Washington medical men was much the same, and to-day, in the light of our experience with the use of alum all over the world, it is hard to see how intelligent men could have been so blind. It is a fact, however, and an interesting fact, in the history of our subject.

We are now catering in water supply to taste and comfort almost as much as to health. We are advancing from water supply as an art to water supply as a science. And here as everywhere we are assisting nature. Sand filtration and storage we must still employ, but these are not always sufficient. Nature often breaks down under unnatural conditions. Art and science must come to her aid. That they are doing so already in water supply science is obvious to any one who reads the signs of the times.

In connection with this fact, — that we are now entering upon a period of water refining, — it ought also to be said that the American public appear ready and glad to pay for such refining.

But it is a curious and interesting fact that they are as yet unwilling to do the same thing for the refining of milk. A little increase in the water rates for the benefit of an improved water supply, even in respect to its refinement, is, as a rule, cheerfully borne by a community, but any increase, however small, in the price of milk, which shall make it cleaner and safer and more abundant, has generally met with bitter opposition on the part of the consumer and almost everybody else except the producer. The human animal is a strange beast. It seems sometimes as if he was intelligent only in spots, — just as he is clean only in spots and moral only in spots. I congratulate this Association that in respect to water, at any rate, he does appear to be ready to meet the necessities of the case and to pay more for refined water than for unrefined, just as he cheerfully pays more for refined than for unrefined sugar.

SOME WATER-WORKS EXPERIENCES IN HARTFORD, CONN.

BY CALEB MILLS SAVILLE, CHIEF ENGINEER, HARTFORD WATER WORKS, HARTFORD, CONN.

[*Read December 8, 1916.*]

INADEQUACY OF SUPPLY.

The inadequacy of the present works supplying water to the city of Hartford was recognized considerably over a decade ago, but, due to different causes and combinations, the project did not take definite shape until the latter part of the year 1911. After this, owing to legal and land questions, the first contracts for an additional supply could not be let until nearly a year later.

The present source is a series of six reservoirs for storing surface water gathered from the easterly slope of Talcott Mountain, and is located about six miles west of Hartford City Hall. In extremely dry years this source is estimated to be able safely to yield about 7.5. m.g.d. Although in average years a yield in the neighborhood of 9.5 m.g.d. can be counted on, it has, however, been very disquieting, to say the least, when the reservoirs have been depleted to such an extent that only a few hundred thousand gallons remained in storage. This has happened twice within the past five years, and in one year during this period the reservoirs failed to fill. Due to the metering of nearly every connection in the city, the consumption of water in Hartford has been kept at a rate of about 66 gal. per capita. The population of the city, however, has increased rapidly, and the increase in the amount of water used has been within proper limits. In 1905 the consumption was 6.8 m.g.d.; in 1910, 7.7 m.g.d., and for 1915 the amount will not be far from 9.4 m.g.d. Works for an additional supply are now in process of construction, and, with these completed, it is estimated that at least 30 m.g.d. will be added to the present supply in periods of greatest drought. This water, however, will not be fully available until early in 1918, but

the works have proceeded to such a point that in case of emergency some help can be obtained from them. Hartford, therefore, is now for the first time in many years beginning to be freed from the threat of taking emergency water from a polluted source, and the beginning of the end of water shortage for many years to come is now close at hand.

In the years 1908 to 1914, inclusive, all New England and neighboring territory passed through a period of extremely low rainfall, and Hartford also was very close to water famine during the entire time. What emergency measures were taken in the face of this danger will be briefly stated. The problem was not a new one in the history of the Hartford Water Board. To meet similar conditions in 1899–1900, two Worthington pumps with a nominal capacity of 5 m.g.d., together with necessary boilers and other appurtenances, were purchased and temporarily installed on the bank of the Connecticut River north of the stone bridge, at an approximate cost of $14 700. Soon after this, however, rain fell in abundance and it was not found necessary to use the plant.

In the report for the year 1908, it is stated that, "owing to the peculiar climatic conditions of the past season, the depletion of the reservoirs was very great and caused the members of the Water Board much anxiety." When the water in the reservoirs reached a point where there was barely enough to supply the city for three months, it was decided by the Board to lay a pipe line from the Farmington River to such a point that water could be pumped through it over Talcott Mountain and then flow by gravity into the Hartford Reservoir System. About $15 000 was spent for cast-iron pipe for this purpose, but the rains came on and the necessity at that time was averted. The next year, 1909, conditions of run-off did not greatly improve, and experiments were made to ascertain if a temporary supply could not be obtained in the vicinity of the Connecticut River, by means of driven wells. These experiments were unsuccessful, as the quantity was not sufficient to warrant the expense of a plant, and the water itself was so highly impregnated with iron as to be practically worthless for domestic purposes. Attention was again turned to the Connecticut River as a source of supply.

Mindful of an epidemic of typhoid fever that had appeared in the city the last time water from the Connecticut River was used, experiments were made for disinfection, using hypochlorite of lime. The results of these experiments seemed to justify the conclusion that an effluent free from typhoid germs could be produced by the use of 1.5 parts available chlorine per million parts of water. The reservoirs again filled, however, before it was necessary to use this water, and the emergency plant was not required. In 1910, a shortage of water being again feared, the Connecticut River pumps were once more given attention, and the entire plant put in condition for use at a cost of about $5 000. In 1911 the reservoirs failed to fill during the spring, and much anxiety was felt concerning the supply. Early in the fall, however, due to very heavy rains in October, the reservoirs were completely filled by the first of 1912. The first of June the water in the reservoirs began to drop, and there was a steady depletion of storage all through the summer and fall. Once again the river pumping plant was overhauled and made ready for use. The results of careful investigations and tests at this time plainly showed that the plant was in no condition to combat a serious shortage. Various means of meeting the emergency were considered, most of which included the use of river water to some degree. No one wanted to use this water, and it was desirable to keep it out of the pipe system, even if it were sterilized. As affording some slight relief, pressures throughout the city were reduced about 12 lb. by throttling gates on the main supply pipe lines, and it was estimated that this action resulted in a saving of about one third of a million gallons of water per day. Again, however, the rains came in time, the reservoirs filled, and the danger of shortage was over for a while. During the succeeding summer the reservoir storage fell at a rate which had become usual during the past five years. In November and December, due to heavy rain and mild weather, the storage started upward but the reservoirs did not become filled until the last of May, 1913. They then almost immediately started down again at the customary pace, until a very heavy October rain with succeeding lighter falls added nearly 700 million gallons in fourteen days, and the danger was past for that year. Starting with full reser-

voir storage of about 2.1 billion gallons, the last part of May, 1914, the reservoir storage began to drop so that early in August serious consideration was again given to the matter of an emergency supply. The supply line connecting the additional supply works with the present reservoir system had been completed, and the first thought was to augment the supply by drawing water from one of the feeders of the proposed reservoir. It was realized, however, that the flow of Phelps Brook could be relied upon to furnish only a comparatively limited amount of water should conditions become really serious. On this account it was decided, therefore, to use the brook water so far as available and also, in order to be prepared for ultimate necessity, to authorize the construction of works for obtaining water from the Farmington River. As had been the case two years previously, throttling of gates was again resorted to, with the result of a saving of about 300 000 gal. per day. This means of conserving water will be taken up in detail later.

Emergency Works, Farmington River.

The Connecticut River source had been mentioned but was not seriously considered on account of local sanitary conditions, the nominal inadequacy of the pumps to furnish a sufficient supply if the necessity for use actually came, and the practical certainty that the plant could not be relied upon for constant service if started. The Farmington River offered a source for auxiliary supply which, while known to be polluted and in other ways far from ideal, nevertheless offered advantages for an auxiliary and emergency supply that outranked other practicable sources. The advantages of this source were the following:

A pumping station could easily be constructed on the Farmington River banks near the new supply pipe line, and, through this and the new conduit, water could be delivered into the present reservoir system.

A high-voltage electrical line crossed the river at this same point, and power for operating the pumps was immediately available.

Regarding pollution, there was little choice under ordinary conditions between the Farmington and Connecticut rivers, but even what there was favored the former source.

Regarding the disinfection and sterilization of the effluent from the two sources, there was much in favor of the Farmington River supply. In the case of the Connecticut River, the only reliance was a hypochlorite plant forcing the chemical into the suction main of the pumps which discharged directly into the distribution system with little or no time for action. In the case of the Farmington River water, double hypochlorite treatment and sedimentation for some hours in the reservoir was possible before the water reached the city. Besides this, variations of wind, tide, and sewage discharge in the vicinity of the Connecticut River station brought about constantly changing conditions at the intake. In the case of the Farmington River station, pollution conditions were very uniform, and a long reach of slowly flowing water above the station was recognized as being of very great value from a sanitary standpoint. The total cost of the emergency plant constructed on the Farmington River was about $13 500, including land, pumping station, electrical and hydraulic machinery, and all incidentals and appurtenances required to deliver water into Reservoir No. 1.

As designed and built, the pumping station has a capacity of 4 m.g.d. Provision was made for the immediate addition of another pumping unit should it be required; the discharge main was of ample size for any ordinary expansion of the plant, and by comparatively inexpensive construction the intake could be extended if necessary. The discharge main from the pumps connects with the 42-in. main through the inspection manhole on top of a blow-off branch in that main. The cover of this manhole was unbolted and a specially cast flanged riser bolted on to the flange of the blow-off.

As stated above, the station is located on the banks of the Farmington River near the crossing of the Nepaug Pipe Line. This pipe line is of cast iron, 42 in. in diameter, and has been constructed recently to bring water from the new supply to the present reservoir system. Starting from the gate-house at the Phelps Brook dam, it extends about 7½ miles southeasterly to the westerly entrance of the concrete conduit, also newly built. By means of this conduit, a half-mile tunnel and an additional mile of conduit yet to be built, water will ultimately be delivered

into Reservoir No. 5 of the present system. From the open easterly end of the concrete conduit, by means of a short section of open ditch, water can be delivered into a brook which flows into Reservoir No. 1, the present distributing reservoir of the city works. Along the pipe line the location of the pumping station is about 3 000 ft. west of the entrance to the conduit, which is also the summit over which water was to be pumped. On account of local conditions, a centrifugal plant, electrically operated, seemed to offer the best solution of the pumping problem, and tenders for the construction and installation of this plant as a whole were invited from several large engineering and contracting companies. A comparison of the figures received and an estimate, based on the plant being furnished by the city and a contract for construction of station and installation of machinery, indicated that quite a substantial saving could be accomplished by the latter method. The final result showed that this decision was not a mistake. Besides the actual saving, the city was enabled to proceed step by step in the matter, watching the reservoir storage depletion and placing orders for plant only as seemed necessary to meet conditions. The pumps had to be made to order, and from four to six weeks were required for this purpose. The electrical machinery was standard and could be furnished in open market provided only that it was in stock. The following were the conditions of service proposed for the pumps:

Pumping capacity	1 400 g.p.m.
Static delivery head	178 ft.
Suction lift	20 ft.
Friction through 50 ft. of suction pipe, including elbows and foot valve	2 ft.
Total dynamic head	200 ft.

Current available, 11 000 volts, 3-phase, 60-cycle.

Proposals for furnishing the pumping machinery were received from five well-known and reputable concerns, the prices varying from $650 to $1 164. After careful consideration of the figures,

taking into account the time in which the pumps could be finished and the ability of the plant to meet the requirements without change or delay, the purchase was made from the Alberger Pump & Condenser Company, who guaranteed a pump efficiency of not less than 70 per cent. operating at full load speed of a 1 200 r.p.m. synchronous speed, 60-cycle induction motor transmitting 100 brake horse-power to the pump shaft. This concern also agreed to ship one unit within three weeks of the date of order and the second unit a week later. In order that there might be no delay in having the plant ready for service, a contract was also made with the pump company to furnish the motors, subject, however, to withdrawal of this portion of the order within two weeks if water conditions were such that work on the pumps could be suspended.

The pumps furnished were two 10-in. Alberger Type "v" turbine pumps, having cast-iron casings, bronze impellers, bronze diffusion vanes, and bronze-covered steel shaft where in contact with the water, mounted upon common extended cast-iron base plates and direct connected to the motors with flexible couplings.

The motors were two 100 h.p. General Electric, Form K, 1 200 r.p.m. synchronous speed, 2 200-volt, 3-phase, 60-cycle, squirrel-cage induction motors, complete, with hand-starting compensators and necessary potential transformers. Besides this the pump company furnished two Crane Fig. 547, 12-in. to 10-in. cast-iron reducers and two Crane Fig. 395, 12-in. combination foot valves and strainers.

For the erection of the temporary station and the installation of the machinery furnished by the Board, a contract was made with Fred T. Ley & Co., Inc., of Springfield, Mass.

The current available from the power line passing the pumping station was 11 000 volts, which it was necessary to step down for use with the motors installed. After consideration of cost and availability, should another pumping unit be required, it seemed desirable to install transformers with capacity sufficient to handle the power required for a third pump.

Ground was broken at the station on December 2, 1914, and the work proceeded rapidly until about January 1, when, on account of heavy rains and flood, temporary suspension was necessary.

These same rains and floods, however, caused considerable increase in the reservoir storage, and, while the danger of water famine was by no means past, the necessity of extreme haste was eliminated. A period of very cold weather now set in, which made outside work difficult and expensive. Under these conditions, as the work was being done on a cost basis, it seemed wise to suspend operations until a more convenient season.

By the middle of February, 1915, the construction and installation work being completed, the Alberger Company were notified that the pumps were ready for inspection by their erecting man, previous to running the acceptance test. The first test was made of both pumps February 21, and neither came up to the requirements of the guarantee, due to priming troubles, electrical starting apparatus, and a hot bearing on one pump. On March 12 a second test was run, and the north pump made a satisfactory showing, giving at 200-ft. dynamic head a discharge of 2.14 m.g.d., with an efficiency of 74.5 per cent.

A preliminary trial of the south pump indicated clearly that something was wrong. This pump was taken apart and a chip of wood 6 in. x 2½ in. x 1½ in. and a piece of coke about 6 in. long and about 1 in. square were found in the impeller. As this was thought by the pump engineer to have caused the trouble, no further search was made. On another test, however, the pump still failed to come up to the guarantee, although the performance was much more satisfactory. Again the pump was taken down and an aluminum bronze bushing was found either too tight in the shaft or else defective. A final and satisfactory test of this pump was made on March 29. At 200-ft. total head, the discharge was 2.03 m.g.d. with an efficiency of 72.6 per cent. (See Table 1.)

There seem to be at least two lessons to be drawn from these testing performances: First, acceptance tests should invariably be made in place and under as nearly as possible working conditions. Shop tests furnish interesting and valuable information but are made under such different conditions from those under which the pump is to work that the results can hardly be compared. Manufacturers' guarantees, no matter how reliable the firm or how honest the intent to meet requirements, should not be taken

TABLE 1.

TEST OF 10-IN. ALBERGER CENTRIFUGAL PUMP 7005, AT FARMINGTON RIVER STATION, ON MARCH 29, 1915.

(South pump in station.)

Test No.	Press. Lb. Sq. In.	Head. Ft.	Suction Hd.			Total Hd. in Ft.	Weir Measurements.			Speed. R.P.M.	Water. H.P.	Elect. H.P. Input.	Efficiency.		
			In. Mercury.	Ft.			Head on Weir. Ft.	Disch. Corr. for Leak.					Plant.	Motor.	Pump.
								Sec.-Ft.	M.G.D.						
1	77.5	179.	15.2	17.2	Press. gage 4.5' above vacuum gage.	200.7	0.448	3.17	2.05	1 183	72.1	108.9	66.3	91.3	72.6
2	30.5	70.5	18.2	20.6		95.6	.611	5.06	3.27	1 181	54.9	118.6	46.3	90.8	51.0
3	47.4	109.5	17.5	19.8		133.8	.580	4.69	3.03	1 180	71.2	121.3	58.6	90.5	64.8
4	61.4	141.8	16.5	18.7		165.0	.536	4.16	2.69	1 181	77.8	119.1	65.3	90.8	71.9
5	69.9	161.3	15.75	17.8		183.6	.493	3.65	2.36	1 180	76.0	114.1	66.6	91.0	73.2
6	78.4	181.	15.0	17.0		202.5	.436	3.05	1.97	1 185	70.0	106.3	65.9	91.3	72.1
7	85.8	198.0	14.4	16.3		218.8	.361	2.34	1.51	1 187	58.0	95.3	61.0	91.5	66.7
8	77.5	179.	15.1	17.2		200.7	.305	3.10	2.00	....	70.5	...	...	...	...

GENERAL NOTES. Weight of water per cu. ft., 62.4 lbs. Discharge measured by thin-edged weir without end contractions. Weir crest 3.0 ft. long and 2.0 ft. above bottom of flume. Discharge taken from Basin. Measured leakage from flume was 2.75 cu. ft. in one minute = 0.046 sec.-ft.

without verification. Second, no matter what the pump salesman asserts, centrifugal pumps for special service, or unless designed for the purpose, do not have the alleged digestive capacity of the ostrich. As for these particular pumps, the makers did everything

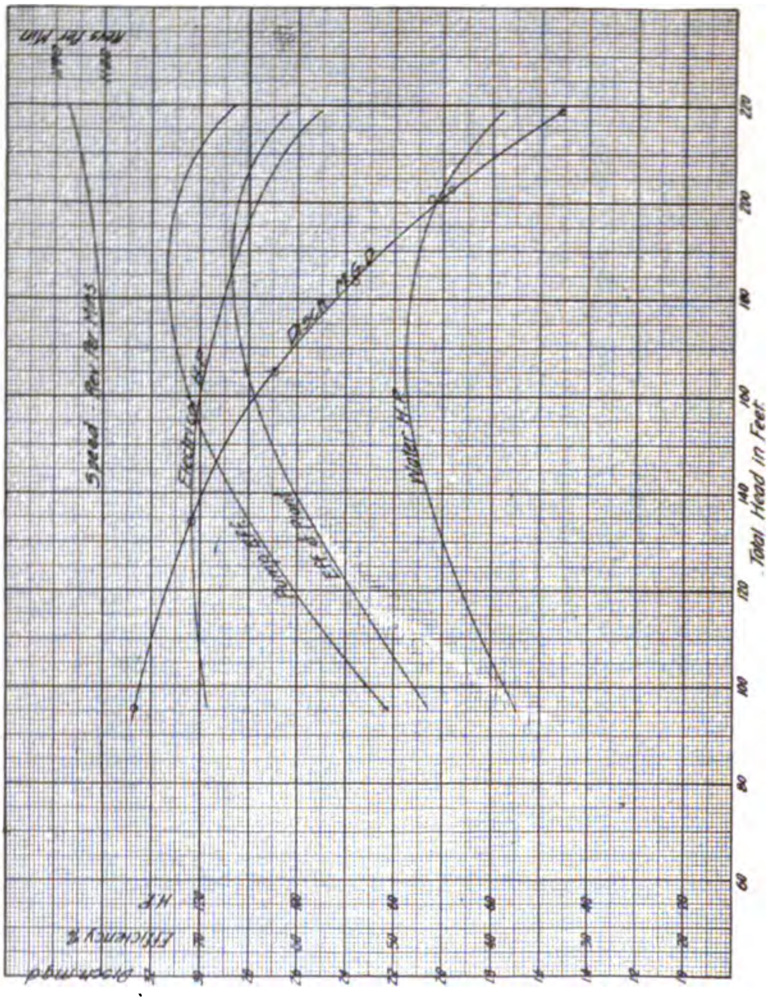


Fig. 1.

Test of Centrifugal Pump, Farmington River Station, March 29, 1915.

in their power to live up to their guarantee, and after being whipped into shape these pumps are, I believe, most capable of satisfactorily fulfilling their purpose.

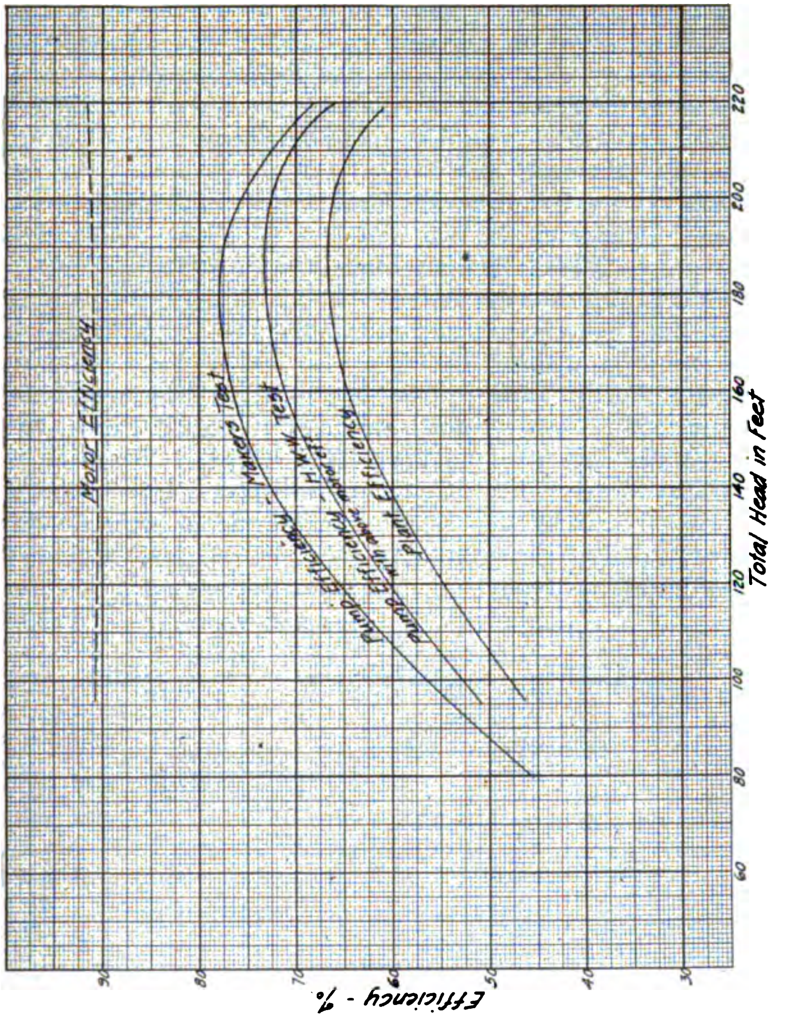


Fig. 2.

Test of Centrifugal Pump, Farmington River Station, March 29, 1915.

The pumps were tested by discharging through the riser branch left in the discharge main for the third pump when installed. A 10-in. gate was strapped on to this branch, into which was leaded a quarter-turn facing southerly; a 10-in. by 16-in. reducer was put into this, and from here several lengths of 16-in. pipe were carried out through the building to a wooden flume. A quarter-turn on the end made the discharge take place at the bottom of the flume, and several baffle plates and a wooden partition bored full of holes destroyed all velocity of approach to a standard thin-edged weir without end contractions. The crest of this weir was 3 ft. long and placed 2 ft. above the bottom of the flume. Heights on the weir were read on a scale placed alongside a gage glass. This was connected to a pipe with several holes in it, that extended across the bottom of the flume. Varying heads for testing were obtained by throttling the 10-in. gate on the discharge main. The log of the test of the south pump is given above in Table 1. The diagram Fig. 1 shows graphically the relation of the test conditions, and the diagram Fig. 2 shows comparative efficiency relations. The efficiency given for the Hartford Water Works pump and plant tests is based on motor efficiency given by the makers. As the motors were standard apparatus, there seems little question but that this efficiency is substantially correct.

Cost.

Emergency Water Supply, Farmington River Station.

Land	$500.00
Temporary pumping station	6 060.91
Gatehouse screens	23.06
Pumps and motors	3 260.00
Foot valves, strainers, and reducers	120.00
Team hire	15.00
Pipe and fittings purchased	563.43
Pipe and fittings from stock	171.92
Transformers and switches	2 131.12
Inspection of pipe and fittings	3.40
Inspection of pumps	15.53
Bolts and gaskets	39.64
Valves	252.50
Rods for holding curves	29.35

Corrugated iron for fence	$23.40
Lumber for flume	29.01
Pipe fittings	2.55
Vacuum gage and repairing same	3.50
Barbed wire	2.04
Hose washers	.10
Leather packing	....
Turbine oil	3.25
Hand bellows	1.25
Speed counter	3.00
Hasp	.25
Electrical supplies	9.99
Repairing vacuum gage	1.50
Signboards	20.14
Lunches at pump tests	28.00
Payrolls — pump tests	123.50
Current for pump tests	41.80
Packing tools	2.25
Drills and tap	.75
Paint and brushes	11.70
Total	$13 493.84

Throttling Gates.

The water supply of the city is brought to the distribution system through three supply mains, one 30-in. line entering the southwest part through Park Street, and two 20-in. lines entering the central part through Farmington and Asylum avenues. Ordinarily the pressure at City Hall varies from a minimum of 58 to 60 lb. from 7 to 10 A.M., to a maximum of about 72 lb. between midnight and 4 A.M., the respective rates for draft at these periods being 14.65 and 4.8 m.g.d.

Because of the fact that the discharge of water is dependent on the head or pressure forcing it through an opening, it goes without saying that if the pressure is reduced the discharge also falls off. What the relation may be depends upon local conditions which are not material to this discussion. During the scarcity of water which has been mentioned above, many means for conserving the supply were tried, and among others the method of reducing pressure in the distribution mains by throttling of gates in the supply mains. This method was tried in Hartford two

years ago and resulted in a saving of about 300 000 gal. per day, estimated from the Venturi meter record at the effluent gatehouse. Because of the importance of this matter and its relation to fire protection, four old and reliable employees, whose regular work was the maintenance and repair of the gates, were assigned to this work, one of them being the foreman. Fire-engine houses conveniently located were chosen as stations for these men, and two were assigned to each of two houses, one located 1 600 ft. and the other 900 ft. from the operated gates. From 4 P.M. to 5 A.M. the endeavor was made to hold the pressure in the city a few pounds above that registered during the period of maximum draft and consequently least pressure. It was assumed that any industry having sufficient pressure during the forenoon would not be seriously inconvenienced if the same pressure were maintained at night. That this was correct was evident by the fact that no complaints of any kind were made by consumers.

By careful comparison, the difference in pressure at City Hall and at one of the engine houses (No. 12) was ascertained. A recording pressure gage was installed at the latter place and, by operating a 20-in. gate in Farmington Avenue, the pressure gage at the engine house was kept at such a point that the City Hall gage recorded a pressure a little higher than that shown during the period from 7 to 10 A.M. In order to accomplish this result, the foreman or helper stationed at Engine House No. 12 constantly watched the pressure gage after the main gate was closed until about midnight. During the evening, on account of gradually decreasing consumption, the pressure rises and the gate was throttled down little by little as was necessary to maintain the desired reading.

The operated gates have the following characteristics:

30-in. gate in Park Street requires 243 turns to open wide.
S20-in. gate in Farmington Avenue requires 52 turns to open wide.
N20-in. gate in Farmington Avenue requires 64 turns to open wide.

There is a 6-in. by-pass around the 30-in. gate. Under ordinary procedure the gates are operated as follows:

30-in. gate in Park Street closed completely at 4 P.M.
6-in. by-pass open all of the time.

N20-in. gate in Farmington Avenue closed 52 turns at 6.30 P.M.
S20-in. gate in Farmington Avenue closed 45 turns at 4 P.M.
47 turns at 5 P.M.
49 turns at 6 P.M.
Completely closed at 6.30 P.M.

And this pressure held constant by manipulation of this gate during the evening. At about midnight, on account of practically constant draft until 6 A.M., no additional attention was usually required. All three gates were opened at about 5.15 A.M. The four men assigned to this work from midnight to 5 A.M. slept at the engine houses under the same conditions as the firemen, with similar arrangements of clothing for quick dressing and getaway. Close check could be kept on the conduct of these men from inspection of the autographic chart records on gages located at City Hall and at Engine Houses 3, 12, and 15. From comparisons of official fire alarm time and the chart records, it was found that it took from one to two minutes for the men located at the stations to get to the gates, and from two to three minutes to get on full pressure. During the actual throttling period (about twelve hours) it appeared that the actual reduction in draft was at a rate of about 600 000 gal. per day. Of this it was estimated — and subsequent investigation confirmed the computation — that 3.75 m.g.d. passed through the 6-in. by-pass on Park Street and the remainder through the throttled 20-in. gate on Farmington Avenue. It thus appeared that the entire city was getting proper proportion of the supply and that a sudden draft in any section would be quickly met.

The insurance people are interested, and properly so, in the maintenance of an adequate supply for sprinkler systems. So far as pressure was concerned, that during the throttling period was from 4 to 6 lb. higher than that during the forenoon hours of each day.

Under conditions of piping approved by the Associated Factory Mutual Fire Insurance Companies, 50 sprinkler heads in the top of a four-story building are satisfactorily served when there is available an average discharge for each equivalent to about 12.9 gal. per minute when all are discharging at once. This condition will occur with a street pressure of about 55 lb. per square inch

and a pressure of 20 lb. per square inch at the top of the riser. Under this condition a floor space of about 100 ft. by 50 ft. would be covered with a total discharge of about 645 gal. per minute.

As a part of the fire protection system, all factories maintain watchmen, and the noise of running water even from one or two sprinkler heads should be quickly noticed and investigated. With any adequate system of patrol, long before any large number of sprinkler heads let go, an alarm would be rung in and the gates fully opened to provide for a large fire draft.

Before entering on this work several computations were made as to the effect of a sudden increase in consumption with the gates throttled, and it appeared that a sudden draft of 550 gal. per minute would cause a drop of from four to five pounds. The results so obtained were roughly checked by observation of not dissimilar conditions that obtained when a locomotive filled its tank at the railroad station. This latter matter has been brought before the Association* in reference to the water ram effect of these sudden large drafts on the pipe system. Since then, and in connection with the matter of gate throttling, additional observations were made with the following results:

Time.	Train No.	Standpipe.	Total Draft. Cu. Ft.	Length of Draft.	Rate of Draft.	
					c.f.p.m.	g.p.m.
9.10 P.M.	64	Church St.	506	2 min. 12 sec.	230	1 720
11.14 P.M.	Dinkey	Asylum St.	218	1 min. 15 sec.	175	1 305
11.33 P.M.	66	Church St.	491	2 min. 9 sec.	228	1 710

The first and last of these rates is over three times that of the sprinkler requirements stated above.

From study of the drops on the pressure charts due to these and other similar drafts, it appears likely that a sudden draft at a rate of 1 600 gal. per minute causes a drop of about 11 lb.; and one of 1 300 gal. per minute, a drop of about 9 lb. per square inch in the Hartford system.

On account of the importance of this matter, however, and in

* Journal N. E. W. W. A.

order to have independent confirmation, a test was run at the pipe yard after midnight, and unknown to the men on the gates. A discharge at a rate of 560 gal. per minute was run through a 4-in. Crest meter and maintained at this rate for about fifteen minutes. Pressures at the time of this test were observed on the gage located at City Hall. The resultant drop was about five lb. per square inch. This seemed to indicate clearly that if a large number of sprinkler heads let go at once the drop in pressure would not be much in excess of 5 lb. before a fire alarm could be turned in and the gates on the supply lines opened.

But possibly some one will say the tests show up well and probably would work out in practice, still it would be more satisfactory to have a practical demonstration. It was furnished under most adverse circumstances at a fire the morning of December 13, 1912, about 500 ft. from fire station. Fire was discovered in a hay and grain storehouse in one of the congested parts of the city. Two alarms, 10 pieces of apparatus, and 8 streams were required. The pressure chart shows that there was full pressure available in the mains when wanted. It is also shown that the pressure was reduced about 10 lb. at 3 P.M., gates opened at about 7.30 A.M. and 12.30 A.M. for previous alarms, and in each case closed down after the all-out signal. The fire was located not far from a gage station, and the pulsations of the streams are very plainly shown on the chart, as is also the withdrawal of several of them a little after 3 A.M.

Regarding the conservation of water from reduction of pressure, it is understood that this method has been in use on the Brooklyn, N. Y., supply for many years with no trouble. Also that as a result of an experiment in cutting down night pressure in Philadelphia, a saving of five million gallons per day was recorded without inconvenience to residents.

OLD CAST-IRON PIPE.

Ground was broken for the Hartford Water Works in 1854, some of the pipes laid in that year are in use, and about 15 miles of pipe laid between 1854 and 1861 are still in service.

Old Cast-Iron Pipes in Service, 1915, Hartford Water Works.

Year Laid.	Length in Feet.							
	3-in.	4-in.	6-in.	8-in.	10-in.	12-in.	16-in.	Total.
1854			1 921	2 326		1 060		5 307
1855			3 071	1 945	2 525	2 361	6 864	16 766
1856	442	193	13 852	4 113	1 072			19 672
1857		1 220	13 479	6 238	457			21 394
1858		811	780					1 591
1859		3 351	4 882					8 233
1860			2 177					2 177
1861			3 438					3 438
Total	442	5 575	43 600	14 622	4 054	3 421	6 864	78 578

Wrought-iron, cement-coated mains came into vogue in 1863 on account of the comparatively low cost, and for a number of years no cast-iron pipe was laid in Hartford. Owing to its greater reliability, cast-iron gradually replaced the cement-lined pipe, and only a comparatively little of this latter pipe is now in use in the city. It is interesting to note that probably the most of the old cast-iron pipe is uncoated and was cast in a horizontal position instead of vertically as at present.

During the past year, new pipe has been laid in many streets formerly served by pipes laid many years ago. This action has been taken not because intrinsically the pipe had worn out or become useless, but solely because the community served is now a populous city district rather than a sparsely settled suburb. The iron in this old pipe was of excellent quality, and, except for the cost of salvage, it might well have been used elsewhere. The cost of removing these pipes, however, is usually found to exceed their value on account of other underground structures, street railway tracks, and improved street surfacing, to say nothing of the often very erratic alignment of the old layout. Some of the pipe is badly tuberculated and other partly filled with sediment, but if the pipe had not been too small for modern requirements in this district, it propably would have paid to clean it. So far as permanency goes, all of this pipe shows that cast iron is an ideal material for water pipes and that up to the present time no

other substance has been found from which generally such satisfactory results can be obtained. There are three principal features to be considered in selecting water pipes — permanency, carrying capacity, and cost. Fifty-five to sixty years' service, and a condition such that life ahead cannot be estimated, certainly meets the first requirement. Well-laid clean or cleaned cast-iron pipes have a carrying capacity not greatly inferior to that of any other materials that have been used, and, if capitalized cost based on longevity of service is taken as a criterion, it appears that all these requirements for water pipes have been met.

So far as possible, when these old pipes are replaced, an endeavor is made to get some idea of their condition and capacity. The condition is obtained from an inspection of sections cut from the main. The capacity is found by discharge tests. In these tests the quantity is obtained either by using a meter or by pitometer, pressure gages placed near the inlet and outlet ends of the pipe giving fair information regarding friction losses under varying conditions of flow.

Meters of standard makes are used on the tests, and these are tested before and after. The gages are 6-in. Crosby Standard Test Gages, graduated in pounds per square inch from 0 to 120 with corresponding heights of water in feet from 0 to 277. These gages are tested on an oil testing machine before and after using, in the position as used on the pipe test, and proper corrections made for error in registration due to this cause. Below are given summaries of the tests of several pipe lines which had been in actual use for a considerable period.

Street.	Size.	Length. Feet.	Age. Years.	Inspection Number.
1. Kennedy Street........	4-in.	670	57	D-328
2. Wooster Street.........	4-in.	962	58	D-330
3. New Park Avenue......	6-in.	1 280	41	D-356
4. New Park Avenue......	6-in.	1 126	13	D-354
6. New Britain Avenue....	6-in.	1 200	18	D-363

The results of these tests are plotted on Figs. 3, 4, 5 and 6.

No discussion will be attempted, at this time, of the problems suggested by these tests, as it is hoped at a later date to have more information regarding the depreciation in carrying capacity of

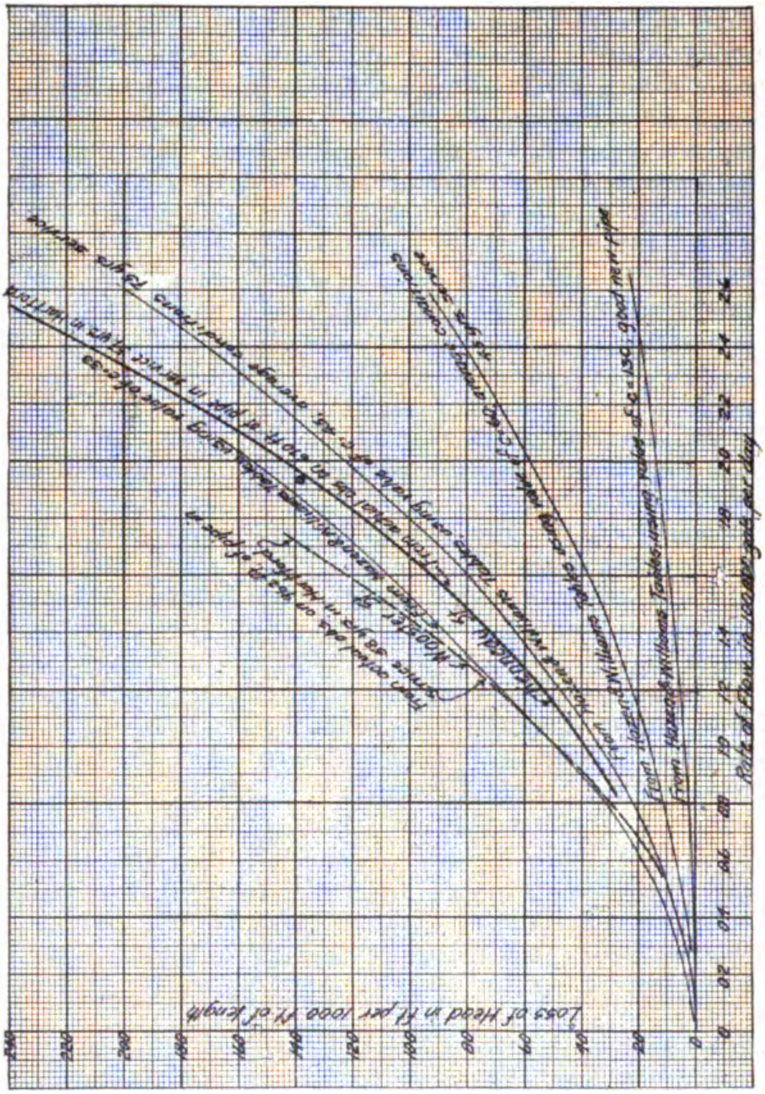


FIG. 3. LOSS OF HEAD IN 4-IN. CAST-IRON WATER PIPE. IN USE OVER 50 YEARS IN HARTFORD.

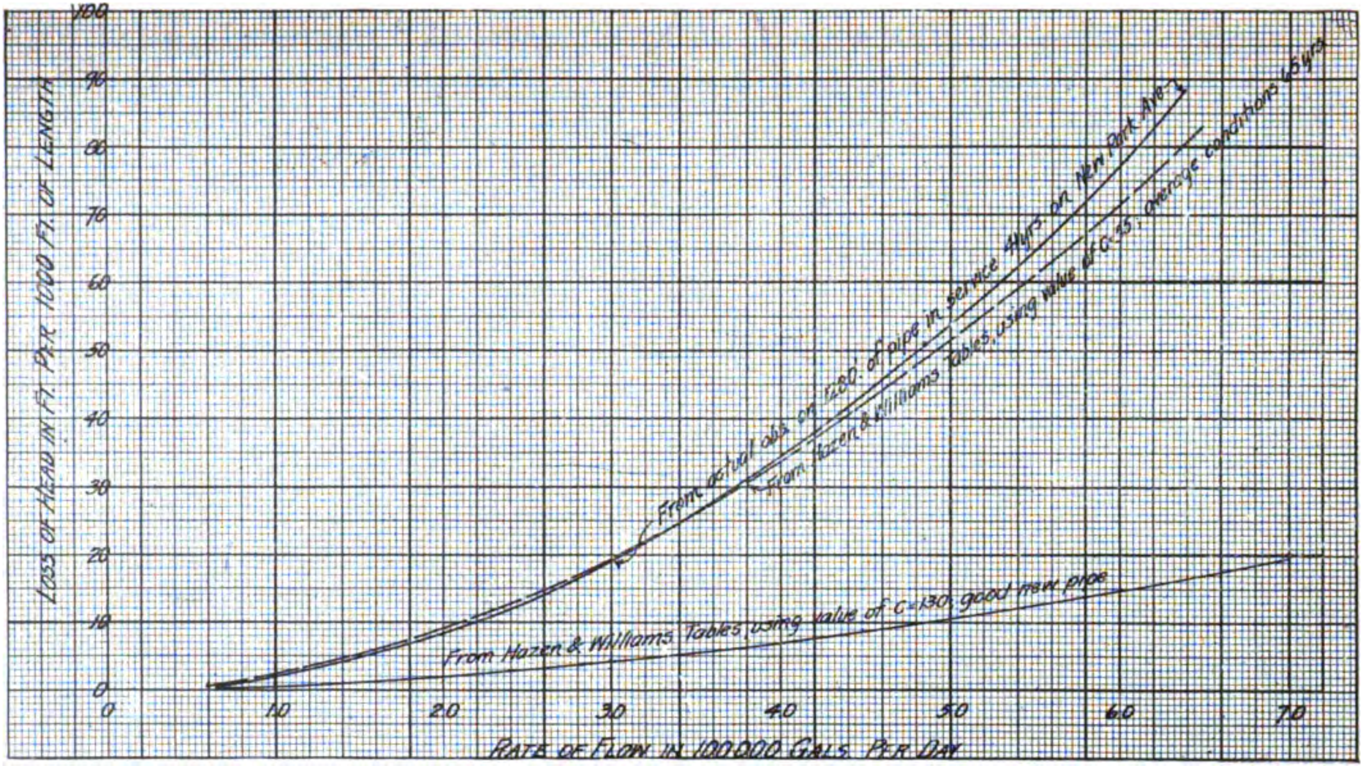


Fig. 4. Loss of Head in 6-in. Water Pipe. In Use about 41 Years in West Hartford.

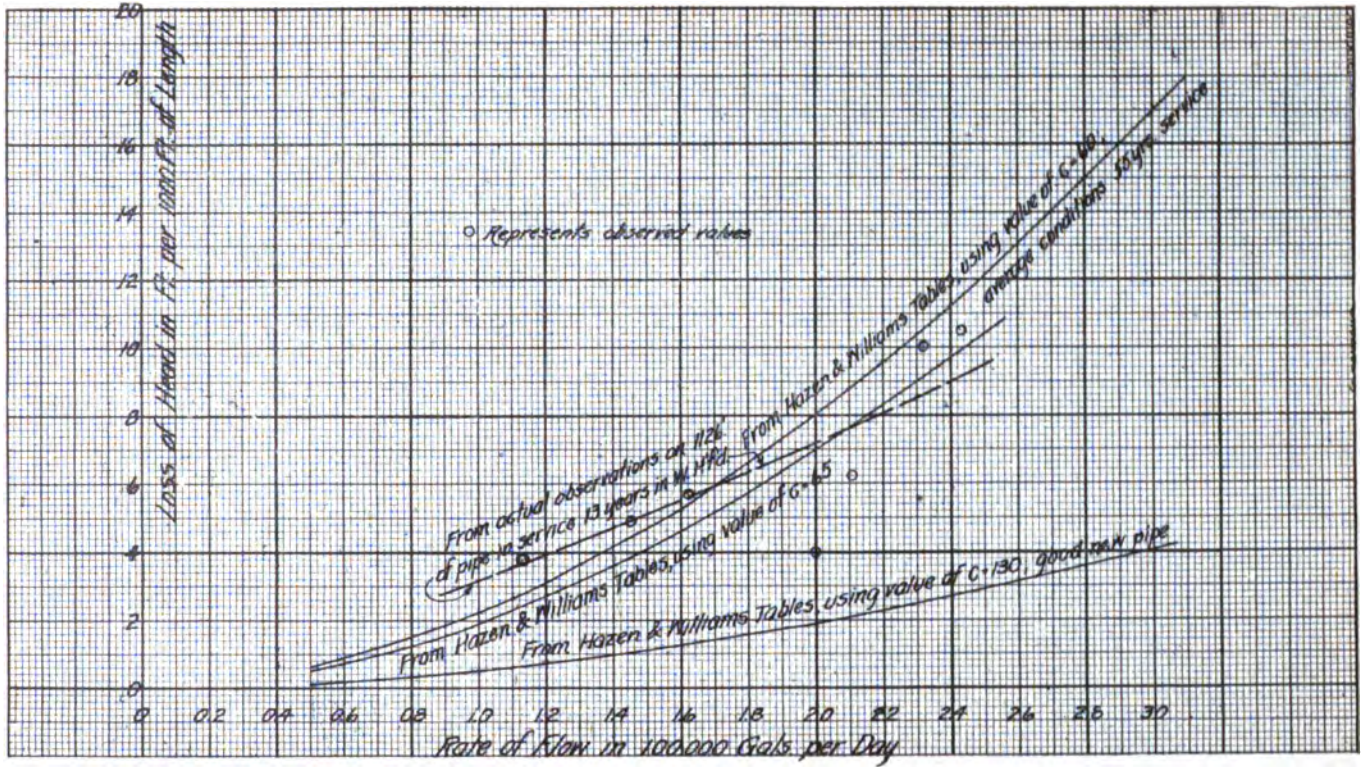


FIG. 5. LOSS OF HEAD IN 6-IN. CAST-IRON WATER PIPE. IN USE ABOUT 13 YEARS IN WEST HARTFORD.

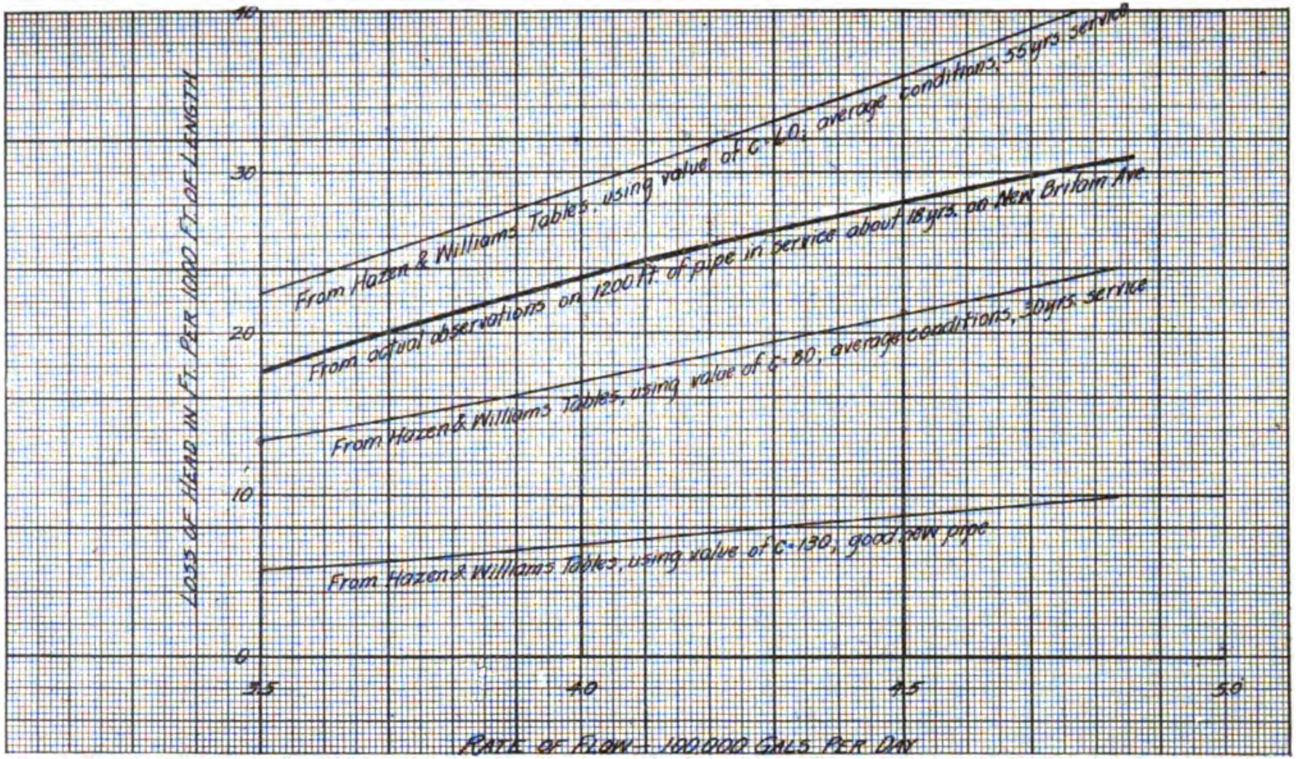


FIG. 6. LOSS OF HEAD IN 6-IN. CAST-IRON WATER PIPE. IN USE ABOUT 18 YEARS IN HARTFORD.

cast-iron pipe after period of service under Hartford conditions. In general, it may be noted that the curve derived from experiments follows closely the shape of those plotted from the Hazen-Williams formula, although they do not agree as to age. This difference is probably due to character of incrustation and other impediments of local significance. It is perhaps of interest also to note that a 4-in. pipe about fifty-seven or fifty-eight years old has a carrying capacity equivalent to a smooth pipe 2½ in. in diameter. Such condition must necessarily have a bearing on the matter of estimating present values of pipe lines which have been laid for a number of years. The worth of a distribution system consisting of cast-iron mains should be based on consideration of adequate size, interior condition and salvage value of the pipes, with little or no account being made of actual depreciation of the pipes except by electrolysis or other special conditions.

Testing Distribution Mains.

During the past three months opportunity has been had to test ten sections of new main pipe aggregating nearly two miles in length. This pipe was laid in city streets by the regular maintenance force of the department. The results are tabulated on the following page.

No definite criterion was set for this work, but the results obtained last year from testing 7½ miles of 42-in. cast-iron pipe of the Nepaug supply main were kept in mind. These tests have been referred to by the writer,* and a tabulation of the results and a diagram show the conditions under which the tests were made.

On the basis of nominal diameters, the leakage from this line under test pressure varying from 100 to 125 lb. per square inch was at an average rate of 0.695 gal. per twenty-four hours per linear foot of pipe joint. It is considerable of a conicidence to note that the average leakage per linear foot of pipe joint for twenty-four hours given for the ten sections of distribution pipe tabulated above is also practically the same.

In the specifications for the construction of the Nepaug Pipe

* Journal N. E. W. W. A., XXIX.

TABLE 2.

DATA FROM TESTS OF DISTRIBUTION MAINS.

Location.	Date.	Size of Main. Inches.	Length. Feet.	Joints on Main Pipe.	Lin. Feet Joint.	Test Pressure Lb. per Sq. In.	Leakage per 24 Hours. Gallons.	
							Total.	Lin. Feet of Joint.
New Britain Ave.	Oct. 29	10	620	54	148*a*	126	140	0.947
Arnoldale Road	Sept. 14	20	2 325	194	1 017	93	130	0.128
New Britain Ave.	Sept. 14	12	1 197	102	320	106	98	0.206
Asylum St.	Sept. 30	12	1 327	115	399*b*	119	432	1.080*k*
Asylum St.	Oct. 16	12	1 070	99	341*d*	125	582*x*	1.700*m*
Seymour St.	Sept. 30	8	1 159	101	224*e*	109	194	0.867
New Britain Ave.	Nov. 12	12	1 054	91	309*f*	125	97	0.313
Allen Place	Nov. 11	8	550	50	113*g*	120	75	0.670
Allen Place	Nov. 5	8	1 076	93	206*h*	120	376*	1.820
Jefferson St.	Nov. 27	8	562	49	109*i*	105	162	1.485
			10 940 = 2.07 mi.		3 086		2 286	0.717

x Ordinary pressure here is 65 lb., leakage at this pressure, 27 gal. per 24 hours.

a Includes 4 6-in. joints. *b* Includes 10 8-in. joints. *d* Includes 4 8-in. and 14 6-in. joints.
e Includes 8 6-in. joints. *f* Includes 15 6-in. joints. *g* Includes 4 6-in. and 2 4-in. joints.
h Includes 6 6-in. and 2 4-in. joints. *i* Includes 4 6-in. joints.
k Includes some leakage at an 8-in. connecting gate. *m* Includes some leakage from an 8-in. gate.

* Large amount probably due to corporation cocks not entirely closed.

Line, the section concerning testing read in part, " The pipe shall be tested . . . under a static pressure corresponding to a water level everywhere of at least 100 ft. above the hydraulic grade line shown on the contract drawings. . . . The entire leakage of any section . . . shall not exceed a rate of 2 gal. in twenty-four hours per linear foot of pipe joint, the length of joint to be figured on the nominal interior diameter of the pipe." The amount here given was decided upon only after careful consideration of the results of tests elsewhere, and the intention was to set such a limit that, on the one hand, excessive joint leakage would be guarded against, and on the other the cost of the work would not be increased considerably by too severe requirements. Observations of working conditions, experience in testing, and the results obtained from the tests showed that the leakage allowable might well have been set at least one half the limits given without calling for any special precaution or unusual care on the part of the contractor.

In his paper before this Association, September 9, 1914, Mr. E. G. Bradbury * proposed as a standard for allowable leakage in cast-iron water pipes an average of 100 gal. per inch mile, equivalent to about 0.8 gal. per foot of lead joint for each complete contract or district, with a maximum of double this for any single test. The testing of pipes discussed in this paper shows that the proposition of Mr. Bradbury would set requirements well within the results which were obtained.

In the tabulation and elsewhere, results are given in terms of linear foot of pipe joint, which seems to be the most logical unit. Nominally, pipe joints are 12 ft. apart; practically, they are seldom or never this distance. For example, on the 7½ miles of 42-in. pipe, the average laying length between joints was 11.75 ft. On the section of distribution pipe given in the table, the laying length has varied from 10.8 ft. to 12 ft. If there are many specials or cut pipe, the laying length may be reduced considerably below that given above. As the unit — " inch diameter per mile of pipe " — must be deduced from the length of pipe joints actually exposed to leakage, the actual number of joints makes considerable difference in the result. Besides this, in almost every line

* JOURNAL N. E. W. W. A., XXVIII, 321.

there are branches and connections having various sized joints differing from those on the main line. These must be considered in getting a unit for expressing leakage. All of these conditions readily fall in with "leakage per linear foot of joint," and for this reason that unit is considered to be well adapted for the purpose of comparing leakage for different pipe lines.

In running tests on distribution mains, sections between gates are ordinarily taken. The intention is to apply about 40 lb. pressure to the section under test in excess of that which ordinarily is to be expected. Wherever possible, the section is subjected to several different pressure heads during the test, with the intention of obtaining data as to the character of the leakage. While the information is not yet complete, the indication is that, with no gates or corporations open or joints blown out, the loss of water, as might be expected with thin openings, varies nearly directly with the pressure. With this in mind it is possible to make very reliable deductions as to the kind of leak to look for when an excessive draft is shown in the test.

The apparatus used in testing is the ordinary force pump for clearing obstructions from service pipes. Usually the pump is a single cylinder, hand-operated force pump, two inches diameter piston and four-inch stroke operating from a small tub. The capacity of this pump under 100 lb. pressure has been found to be about 2 gal. per minute. The quantity passing the pump is measured by an ordinary meter of small size. The cost of testing, including all labor, material, and supervision, has averaged about $6 per test. On the Nepaug pipe line, where conditions were somewhat different, the cost of the work was about four cents per linear foot of pipe, or $200 per section tested. In this case a steam pump was necessary to fill the pipe, and the cost included the setting up and operation of this plant and oftentimes also the laying of long lines of small size pipe.

Foundry Rejections of Cast-Iron Pipe.

During the past four years the Hartford Water Department has purchased about 16 750 tons of cast-iron water pipe. Of this, 10 886 tons was 42 in. in diameter for the Nepaug pipe line and

5 864 tons of sizes varying from 4 to 24 in. in diameter for ordinary needs of the distribution system.

Inspection is paid for at a rate per ton of pipe actually inspected, whether or not accepted on the order. Table 3 gives data concerning the amount of pipe inspected, purchased, and rejected on the smaller-sized pipes for the distribution system, the maximum rejection being 61.9 per cent., and the minimum, 3.2 per cent. In the total it appears that there was an average of about 11 per cent. of rejections; or, in other words, for every ton of pipe accepted, 1.124 tons were inspected. If the inspection charge was 25 cents per ton, this would mean an actual cost of about 28 cents per ton for the net quantity purchased. The causes of these rejections are, of course, oftentimes unavoidable, but an inspection of Table 4 will show that probably careless foundry methods are responsible for a large part of this trouble. Since this matter has been in my mind, I have been watching the reports from the various foundries from which we have purchased pipe and I find that there is considerable difference in the amount and character of the rejections. This being the case, the conclusion seems obvious that, as stated above, carelessness, lack of skilled help, and improper iron mixture are responsible, in part at least, for a large number of rejections. If this is so, a method of correction, perhaps, would be to set a limit to the total amount of rejections that would be allowed and deduct from the pipe bill the amounts of the inspector's charge in excess of this amount. As a question for discussion, I would suggest 10 per cent. as the maximum amount of rejections to be paid for by the purchaser, amounts in excess of this to be borne by the foundry. An alternative of this suggestion might be to allow the foundry to submit only such pipe as they choose for inspection, and then to charge against the foundry all cost of inspection in excess of, say, 5 per cent. The reason for setting 10 per cent. as the limit was reached after study of the percentages from the several foundries. It was found that about 3 000 tons, or 45 per cent. of the total inspection shown in Table 3, varying in sizes from 4 to 20 in. in diameter, was furnished by one company. Of this amount of pipe, 75 per cent. was passed with 7.5 per cent. or less rejections, and 33 per cent. with less than 5 per cent. rejections. Some such action as

TABLE 3.

INSPECTION OF CAST-IRON PIPE AND SPECIAL CASTINGS,
HARTFORD WATER WORKS.

(Class E, N. E. W. W. Specifications.)

1912–1915 inclusive.

Size. Inches.	Quantity in Tons.			Per Cent. Rejected.	Tons Inspected for Each Ton Accepted.
	Inspected.	Accepted.	Rejected.		
	Straight Pipe.				
4	141.92	111.69	30.23	21.3	1.213
4	16.37	6.22	10.15	61.9	2.631
4	23.52	20.85	2.67	11.2	1.123
6	17.39	14.58	2.81	16.2	1.192
6	162.80	140.35	22.45	13.8	1.160
6	47.54	39.35	8.19	17.2	1.208
6	22.11	17.18	4.93	22.4	1.287
6	20.52	18.54	1.98	9.4	1.109
6	24.23	20.16	4.07	17.0	1.201
6	26.34	21.79	4.55	17.5	1.208
8	89.46	71.71	17.75	19.8	1.248
8	357.71	320.97	36.74	10.3	1.114
8	116.88	98.42	18.46	15.8	1.188
8	300.48	283.39	17.09	5.7	1.062
8	798.36	744.98	53.38	6.7	1.072
10	513.50	360.16	153.34	29.8	1.425
10	419.27	355.88	63.39	15.1	1.178
10	206.09	190.99	15.10	7.5	1.079
10	282.91	266.25	16.66	5.9	1.064
10	41.80	38.17	3.63	8.6	1.094
12	397.76	334.65	63.11	15.8	1.188
12	141.23	111.69	29.54	21.0	1.261
12	632.11	604.44	27.67	4.4	1.047
12	412.89	379.36	33.53	8.3	1.089
16	131.63	111.85	19.78	15.0	1.176
16	84.49	81.79	2.70	3.2	1.030
16	377.43	364.91	12.52	3.3	1.034
16	122.94	117.70	5.24	4.3	1.045
20	284.85	258.35	26.50	9.4	1.103
24	373.92	357.49	16.43	4.4	1.046
Total	6 588.45	5 863.86	724.59	11.0	1.124
	Special Castings.				
	24.84	19.92	4.92	19.7	1.242
	77.88	62.29	15.59	20.0	1.256
	137.41	100.02	37.39	27.3	1.374

TABLE 4.

Foundry Rejections.

March 15, 1915, to July 24, 1915.

4-in. pipe inspected, 23.52 tons.
6-in. pipe inspected, 24.23 tons.
8-in. pipe inspected, 798.36 tons.
10-in. pipe inspected, 262.25 tons.
12-in. pipe inspected, 412.89 tons.
16-in. pipe inspected, 122.06 tons.
20-in. pipe inspected, 284.85 tons.

Total amount of pipe inspected, 1 928.16 tons.
Special castings inspected, 79.92 tons.
Pipe are Class C, and special castings are Class D.

Defect	4-in.	6-in.	8-in.	10-in.	12-in.	16-in.	20-in.	Specials
Bead bad........		1.06	31.19	0.45		1.75		
Bead broken.....								0.14
Bead raised......		0.44	2.16					
Bell bad.........	0.15							0.47
Bell dirty........				5.67	3.32		5.11	
Blistered........								1.18
Blowed..........						0.88		1.56
Blow hole.......				0.45	0.57			0.20
Coke ring bad ...			0.32					
Core bad........			1.56					
Core blister......					0.57			
Core cut.........								0.11
Core rake.......				0.88				
Core ring........			3.80					
Core rough......		0.44						
Core scabs.......			0.94		22.93		11.20	
Core swells......	0.29							
Cracked.........		0.63	0.32		0.57			0.34
Crooked.........			0.31					
Crushed.........								1.28
Dead iron							1.26	0.26
Dirty...........								0.07
Dirty b. face						0.88		
Dirt hole........				0.43				3.91
Head crushed....		0.21				0.85	2.55	
Head cut........							1.23	
I. ring bad.......			0.31					
Iron inside.......	1.96							
Light...........	0.13		1.47					
Mold bad.......		0.22	0.31					
Mold cut........				0.44	0.45		2.57	
Mold rough......				1.33				
Mold scabs......	0.14			0.44				
Mold strain......			2.19	0.44				
Poured short				1.31				
Run out.........				0.43		0.88		0.15
Scabbed.........								1.38
Socket bad......								0.14

TABLE 4. — *Continued.*

Defect.	4-in.	6-in.	8-in.	10-in.	12-in.	16-in.	20-in.	Specials
Socket cut.......			4.41	0.44				
Socket short.....								0.40
Soft rammed								0.20
Spawled.........								0.15
Thin............								1.17
Uneven..........		1.07	4.09	3.95	1.12		2.58	2.48
Totals......	2.67	4.07	53.38	16.66	33.53	5.24	26.50	15.59

Total amount of pipe inspected, 1 928.16 tons.
Total amount of pipe rejected, 142.05 tons.
Total amount of pipe purchased, 1 786.11 tons.
Percentage pipe rejected of pipe purchased, 7.9 per cent.
Ratio tons inspected to tons accepted, 1.07: 1.00 tons.

Note. — All the above except the 4-in. pipe were bought on contract.

Special Castings.
Tons inspected, 79.92.
Tons rejected, 15.59.
Tons purchased, 64.33.
Pipe rejected to pipe inspected, 19.5 per cent.
Tons inspected to tons accepted, 1.24 tons.

this, I feel sure, would have a tendency to result in fewer rejections and a better class of pipe in the foundries where the present percentage of rejection is quite large. Such conditions, as noted above, indicate also the necessity of careful inspection at the foundry, whether the pipe be cast on order or taken from the stock pile. This reference to foundry shortcomings in no way reflects on cast-iron pipe itself, which I believe to be the best material which has been proposed thus far for distributing water. Neither do these criticisms apply equally to all foundries and makers of cast-iron pipes. Every foundry can turn out first-class products if so desired. Several of them are ordinarily supplying such a high grade of goods that competent purchasers prefer to place orders with them without competition when specially important work is to be undertaken.

Tables 5, 6, and 7 apply to 42-in. pipes purchased for the Nepaug pipe line. Inspection shows that the rejections on this purchase were very reasonable in amount, that percentage of cut pipe was not excessive, and the variation in weight was within the limits stated in standard specifications.

TABLE 5.

CONTRACT 4-A.

	Straight Pipe. Tons.	Specials. Tons.
Total weight inspected	12 049.27	109.9955
Total weight paid for	10 885.88	98.1945
Weight rejected	1 163.39	11.8010
Rejection of total cast	9.6 per cent.	10.7 per cent.
Total number of pipes accepted		3 294
Total number of pipes rejected		352
Per cent. rejected		9.6

TABLE 6.

SUMMARY OF PRINCIPAL CAUSES OF REJECTION OF 42-IN. PIPE FOR CONTRACT 4-A.

Cause of Rejection.	Number Rejected for This Cause.
Mold scabs	42
Core crushed	36
Core buckled	7
Sand hole	19
Shrunk hole	8
Shrunk gate	23
Uneven — light or thin	36
Bad bell	24
Bad bell face	10
Bad bead	17
Socket cut	7
Light	60
Heavy	1
Leaked	26
Miscellaneous	36
Total	352

LOSSES IN FIRE HYDRANTS.

Recently, two tests have been made in Hartford to determine the capacity of the supply and distribution system under conditions of very large draft. Very interesting data were obtained, some of purely local application and other of more general interest. From this latter class is taken the matter of losses in fire hydrants. The hydrant used was a 5-in. standard make. The

TABLE 7.

TOTAL NUMBERS AND WEIGHTS OF 42-IN. CAST-IRON PIPE RECEIVED ON CONTRACT 4-A.

Received at	Class of Pipe, N. E. W. W. A. Specifications.										Specials.	
	B.		C.		D.		E.		F.			
	No.	Weight.*	No.	Weight.	No.	Weight.	No.	Weight.	No.	Weight.		
Burlington			224	711.09	49	169.77	16	61.78	15	64.28	8	10.69
Brick Yard	228	628.36	552	1 760.88	515	1 823.61			20	84.87	23	33.46
Unionville	273	763.32	684	2 183.28	670	2 372.62	34	133.73	14	59.26	48	50.50
Totals	501	1 391.68	1 460	4 655.25	1 234	4 366.00	50	195.51	49	208.41	79	94.65
Av. wt. per length†	5 555		6 377		7 076		7 820		8 506			
Std. wt., do.	5 560		6 270		6 970		7 720		8 360			
Per cent. variation†	—.05		+1.7		+1.52		+1.29		+1.75			
No. foundry cut and av. laying length	34 (11–6)		87 (11–6½)		17 (11–6½)		5 (11–7½)		1 (11–7¾)			
Per cent. of cut pipe	6.7		6.0		1.4		10.0		1.0			

* Weights are in tons. † No allowance made for cut pipe.

TABLE 8.

TEST OF 5-IN. FIRE HYDRANT OF "H" PATTERN WITH FOUR $2\frac{1}{2}$-IN. NOZZLES AND ONE STEAMER NOZZLE.

Test No.	No. of Streams.	Hose No.	Size of Hose Nozzle.	Nozzle Pressure by Pitot Tube Gage. Lb. Sq. In.	Discharge through Nozzle. Gals. per Min.	Losses in Pressure. (Det. by mercury differential gage.) Main to Hyd. Branch. A to B. In. Hg. Lb. Sq. In.	In 26′ of 8″ Hyd. Lateral. B to C. In. Hg. Lb. Sq. In.	In Foot of Hydrant. C to D. In. Hg. Lb. Sq. In.	In Barrel of Hydrant. D to E. In. Hg. Lb. Sq. In.	Pressures. In 24″ Main A. Lb. Sq. In.	In Hyd. at E. Lb. Sq. In.	In Hose No. 4 at Hyd. Lb. Sq. In.
1	1	1	$1\frac{1}{8}$″	67	305	$\frac{1}{16}$″ = 0.03	$\frac{1}{8}$″ = 0.06	$\frac{1}{2}$″ = 0.23	0″ = 0	..	..	..
2	2	1	$1\frac{3}{4}$″	38	560	1″ = 0.45	$1\frac{5}{16}$″ = 0.60	$7\frac{1}{2}$″ = 3.4	$\frac{1}{2}$″ = 0.23	81	75	..
		2	$1\frac{3}{4}$″	41	585							
					1 145							
3	3	1	$1\frac{3}{4}$″	32	515	$2\frac{1}{4}$″ = 1.02	$2\frac{1}{2}$″ = 1.14	$16\frac{3}{4}$″ = 7.6	$1\frac{1}{4}$″ = 0.57	82	69	..
		2	$1\frac{3}{4}$″	38	560							
		3	2″	26	610							
					1 685							
4	4	1	$1\frac{3}{4}$″	32	515	$3\frac{3}{4}$″ = 1.71	$4\frac{3}{4}$″ = 2.16	*12.3	2″ = 0.91	80	61	53
		2	$1\frac{3}{4}$″	37	552							
		3	2″	26	610							
		4	$1\frac{3}{4}$″	35	538							
					2 215							

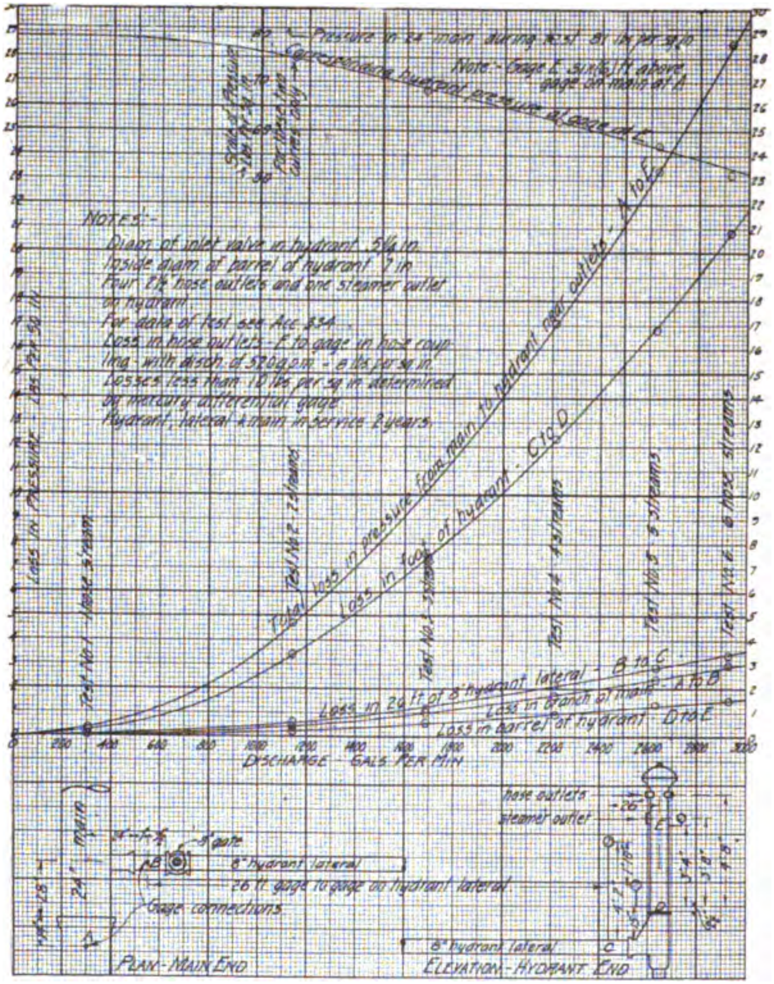
5	5	1	$1\frac{3}{4}''$	31	507	$5\frac{3}{16}'' = 2.36$	$6\frac{1}{4}'' = 2.84$	*16.8	$3'' = 1.36$	81	57	49
		2	$1\frac{3}{4}''$	34	530							
		3	$2''$	24	584							
		4	$1\frac{3}{4}''$	31	507							
		5	$2''$	18	505							
					2 633							
6	6	1	$1\frac{3}{4}''$	25	454	$6\frac{1}{2}'' = 2.95$	$7\frac{3}{8}'' = 3.35$	*20.8	$3\frac{1}{4}'' = 1.48$	81	51	43
		2	$1\frac{3}{4}''$	28	481		Note. Hoses Nos. 1, 2, 3, and 4 attached to hose outlets. Hoses Nos. 5 and 6 siamesed to steamer outlet.					
		3	$2''$	20	532							
		4	$1\frac{3}{4}''$	28	481							
		5	$2''$	17	490							
		6	$2''$	17	490							
					2 928							

* Losses obtained from readings of pressure gages at C and at D as follows:

Test No.	Pressures. Lb. per Sq. In.			Correction for Difference in Elevation of Gages at C and D.	Corrected Loss, C to D.
	Gage at C.	Gage at D.	Difference.		
4	76.5	65	11.5	1′ 10″ = 0.8 lb. sq. in. to be added	12.3
5	74	58	16	0.8	16.8
6	72	52	20	0.8	20.8

Note. Hydrant was on west side of Trumbull Street, opposite Gold Street. One 50-ft. length of $2\frac{1}{2}$-in. hose was attached to each $2\frac{1}{2}$-in. hydrant nozzle, and two 50-ft. lengths were siamesed to the steamer nozzle.

test was run to an extreme limit of discharge. The results obtained do not specially reflect on this type of hydrant, which our



PRESSURE LOSSES IN 5" FIRE HYDRANT ON TRUMBULL ST. OPP. GOLD. AUG 17, 1915

FIG. 7.

experience has shown to be very satisfactory, but are given here as applicable in a greater or less degree to most hydrants now on

the market when used under the conditions of the test herein described.

The data presented indicate what limits of discharge and loss of pressure may be expected under a range of draft. It is believed that the test was made absolutely under working conditions of service, and the data may be taken as of practicable application without the refinements of a testing laboratory.

The data and results are shown in detail in Table 8 and in Fig.7.

A description of the test and the conditions under which it was made may be very briefly stated.

The hydrant was located in a portion of the congested district, and at a point where the ordinary pressure is quite high. The water drawn from the hydrant was discharged into the Park River which flowed nearby. During the final run, 6 hose streams were in service, 4 connected to the 4-hose outlets of the hydrant, and 2 siamesed to the 4½-in. steamer outlet. No special preparation was made for this test, as the intention was to get working conditions as far as possible. The maintenance force of the Water Department excavated the trench of the hydrant lateral which had been laid about two years and tapped in gage connections as shown on the plan and elevation at the bottom of Fig. 7. Mercury differential gages were used when the differences in pressure were rather small, and pressure gages when the difference was too large to be read on the mercury columns. Members of the engineering staff affixed the gages and operated them throughout the test. Fire department men did all the work connected with hose operation under the personal direction of the fire chief, whose interest, intelligent coöperation, and desire to obtain facts applicable to fire department matters has been of the greatest assistance.

The principal loss is in the bottom of the hydrant, starting with an inappreciable amount with one hose stream of about 300 gal. per minute and reaching a loss of nearly 22 lb., or 73.5 per cent. of the total, when the discharge was 3 000 gal. per minute. The advantage of the large lateral from the main to the hydrant is shown by the small losses which occurred there, under maximum flow the loss in the branch and lateral being less than 5 per cent. of the total. Incidentally, it appears that the loss in a 24

by 6 branch is about the same as that in 30 ft. of 8-in. pipe, there being probably some slight loss in the 8-in. gate on the lateral. The hydrant barrel seems of ample size.

The principal conclusion to be drawn from this test seems to be that the water-way at the base of the hydrant should be of more ample proportion, devoid of obstructions so far as possible in the matter of valves and stems and provided with smooth, easy passage for changing the direction of the incoming water. It seems desirable to have large-sized laterals, and a size larger branch from the main with a reducer to the lateral would be of considerable advantage even if a smaller lateral were used.

PUBLIC USES OF WATER.

The average daily consumption of water in Hartford is at a rate of about 9.5 m.g.d., which, with the number of consumers estimated at 143 500, gives a per capita consumption of 65.5 gal. per day. Hartford may be taken as a fully metered city, all of the services being so covered except those intended solely for fire protection purposes. A recent canvass of public uses of water, and a comparison of Venturi meter records from the supply lines with the amount of water paid for, has resulted in the following estimate of the manner in which water is disposed of in this city. On account of the roundabout methods by which some of the figures were obtained, the tabulation is subject to correction when more reliable data are at hand, but those given now are thought to give a substantially correct classification.

Division of Use of Water in the City of Hartford.

Use.	Million Gallons per Day.	Gallons per Capita.	Per Cent. of Total Consumption.
Domestic	4.74	33.0	50.4
Manufacturers and other business	2.73	19.0	29.0
Public	0.43	3.0	4.6
Unaccounted for	1.50	10.5	16.0
	9.40	65.5	100.0

In connection with the matter of the per capita consumption of water, it is interesting to compare the above figure with the

estimate made by the late Mr. Dexter Brackett in his report on "Present and Future Consumption of Water in the Metropolitan District in Boston."

Use.	Gallons per Capita.
Domestic	35
Trade and mechanical	35
Public	5
Leakage and waste	25
	100

Regarding the last item, Mr. Brackett stated that he considered an allowance of 15 gal. per inhabitant for leakage and waste a minimum quantity which could only be maintained by a thorough meter system and constant inspection. As Mr. Brackett was a recognized authority on this subject, and his estimates for the Metropolitan District fully justified, it would appear that water conditions in the city of Hartford are at least normal.

PUBLIC USES.
(Approximate only, and subject to considerable revision.)

Service.	Amount per Year.		
	Million Gallons. Total.	Million Gallons per Day.	Gallons per Capita.
Fire			
Station use	3.7	0.010	0.074
Extinguishing fires	3.3	0.009	0.066
			0.140
Parks	11.7	0.032	0.235
Police	0.9	0.003	0.022
Street			
Drinking fountains	0.4	0.001	0.008
Horse fountains	2.3	0.008	0.059
Sprinkling and flushing	34.1	0.093	0.684
Miscellaneous	0.4	0.001	0.008
			0.759
**Schools*	24.7	0.068	0.498
Miscellaneous buildings	20.8	0.057	0.419
	102.8	0.282	2.073

* Including parochial schools.

Fire Department. The general public seems to have an impression that vast quantities of water are used in the putting out of fires. This is a very erroneous idea, as the total amount of water so used is comparatively small. The rate of demand, however, for short periods is often very great, so great, in fact, that in cities of 100 000 to 150 000 population a reasonable requirement for fire protection service often equals or exceeds the maximum hourly rate of draft of an ordinary day. The total amount of water used by the Fire Department of Hartford in the past year was about 7 million gallons, or a little over a pint per capita per day, of which about one half was used in the maintenance of 16 stations, including washing of hose and apparatus. The remainder was used in the extinguishing of fires.

The following data from Fire Department records of 1914 is an indication of service conditions in this city.

Total actual fire alarms	628
Number fire calls at which water was used	105
Number of times pump service available	63
Number of hose streams in use, average	2
Length of hose line, average, feet	380
Usual size nozzle, inches in diameter	1 to $1\frac{1}{4}$
Average hydrant pressure in service	60 to 80 lb.
Average pump pressure	100 to 200 lb.
Total amount of water used	3 300 000 gal.
Value of property included in the fires	$7 973 109
Insurance thereon	$3 348 310
Insurance loss	$14 590

The following table shows the duration of hose service at fires in 1914.

Number of Fires.	Duration of Service.
50	15 minutes.
25	15 minutes to 30 minutes.
15	30 minutes to 1 hour.
11	1 hour to $2\frac{1}{2}$ hours.
2	$2\frac{1}{2}$ hours to 4 hours.
2	4 hours to 6 hours.

Of the 105 alarms at which water was used, three or more streams were in service at only 16. There were seven calls at

TABLE 9.

ANALYSIS OF THE SEVEN CALLS WHERE FIVE OR MORE STREAMS WERE IN SERVICE.

Date. 1914.	No. Streams.		Length of Time in Service.			Discharge of Stream. Gallons per Min.			Max.	Rate of Discharge.		Equiv. No. 250 g.p.m. Streams.	Estimated Total Amount Water Used. Gallons.
	2½ in.	3 in.	Aver. h. m.	Min. h. m.	Max. h. m.	Aver.	Min.	Max.	h. m.	g.p.m.	m.g.m.		
Jan. 20	9	–	4 20	3 —	6 —	260	240	285	3 —	2 360	5.40	9.5	613 370
Feb. 21.....	11	2	2 35	2 —	4 30	365	175	645	2 —	4 765	6.86	19.1	648 380
Feb. 26.....	8	2	2 20	1 —	4 15	315	260	425	1 —	3 130	4.50	12.5	426 530
May 23.....	5	–	– 30	– 10	1 25	225	200	270	– 10	1 120	1.61	4.5	35 770
Dec. 4......	3	2	1 25	– 35	4 —	335	260	450	– 35	1 665	2.40	6.7	151 220
Dec. 4......	7	2	1 25	– 35	2 10	325	245	565	– 35	2 930	4.22	11.7	239 670
Dec. 18.....	5	–	– 55	– 15	1 30	270	210	300	– 15	1 340	1.93	9.3	67 250

These seven fires used a total of 2 182 190 gal., or about two thirds of the entire amount used to put out fires, leaving 1 117 810 gal. to be used by the other 98 calls, or an average of about 11 400 gal. per fire call.

which 5 or more streams were used, four at which 9 or more were used, and one at which 13 streams were in service.

An analysis of the seven calls at which five or more streams were in service is given on the preceding page, in Table 9.

The largest fire, that of February 21, was in the Union Station, — a sandstone structure with wooden finish and generally large open room space. This building had streets on three sides and an open four-track space on the other. It was, therefore, very easy to reach with water, not difficult to curtail spreading to adjacent buildings, and, due to its stone sides, practically self-contained. The water pressure from the hydrants was at about a maximum, due both to the relatively low elevation of the ground and to the fact that the fire came in the afternoon. With different surroundings and adverse conditions, 50 per cent. more fire streams might easily have been required to keep the fire from spreading. This would have been 28 250-gal. streams, a requirement well within the limits set by the fire insurance underwriters for a city the size of Hartford, and yet this was not a fire that at any time threatened a conflagration.

Under topic "Throttling Gates," page 207, reference is made to a fire in a hay and grain storehouse; this fire was referred to by the writer in his paper on "Water Ram,"* and a table given there is reproduced below in order to show what amounts of water may be called for in an ordinarily bad fire. The Venturi meter on the supply main at the effluent gatehouse indicated a draft for this fire of about 350 000 gal., the rates of draft in excess of the ordinary consumption being as follows:

Ten-Minute Intervals.	Gallons per Hour.	Ten-Minute Intervals.	Gallons per Hour.
1st period	125 000	9th period	110 000
2d	190 000	10th	130 000
3d	200 000	11th	140 000
4th	240 000	12th	100 000
5th	195 000	13th	70 000
6th	160 000	14th	30 000
7th	170 000	15th	20 000
8th	170 000	16th	30 000

* JOURNAL N. E. W. W. A., XXVIII, 185.

It is of interest to note in this connection that in a city of 135 000 inhabitants, with full fire and police protection, there is a possibility during any year of at least five fire calls any one of which may require from 150 000 to 650 000 gal. of water drawn at rates up to nearly seven million gallons per day in excess of a maximum ordinary flow. Also that this rate may be maintained for two to three consecutive hours. In view of the Baltimore, Chelsea, and Salem conflagrations, and the ordinary fire demands of a city the size of Hartford, it seems clear that it would be very well for many towns and cities to look very closely into the capacity of their supply mains.

Park Department. The city of Hartford is noted for the extent and beauty of its parks. Expense has not been spared to develop this wonderful and delightful system, which is thrown freely open to the public with the endeavor to make these open places the people's recreation grounds. The total park area is about 1 325 acres, part of which is in natural wooded condition and part intensively cultivated. The total amount of water used by this department for park purposes was 11.9 million gallons, or about 1 quart of water per day per capita; of this, 8.55 million gallons were used in the House of Comfort and in four public bath houses.

Police Department. The use of water for this department is confined to one central station. The total force comprises about 250 members, all of whom when on duty report at the central station. The total amount of water used by this department is about 900 000 gal. per year, or about 0.022 gal. per capita based on city population. Based on the force reporting to this station, the use of water is about 12 gal. per day, including all purposes.

Street Department. The total amount of water used by this department is estimated to be 37 700 000 gal. per year, or about three fourths of a gallon per capita per day based on population. This use comprises that required by 14 drinking fountains, 12 horse troughs, the sprinkling and flushing of streets, and miscellaneous uses such as stables, yards, and sewer flushing. As a general rule, street sprinkling and flushing continues for from 7½ to 8 months per year. During the winter season the number of fountains and troughs is considerably reduced. During nearly two thirds of the year about 320 250 sq. yd. of asphalt paving are

flushed nightly, and about two miles of 30-ft. roadway regularly sprinkled. As bearing on this subject it is pertinent to state that a very large proportion of the macadam streets in Hartford are oiled and therefore use little or no water during the season.

Schools. The total use of water in the schools of Hartford amounts to about 24.7 million gallons per year, or about three quarters of a gallon per capita of estimated population. Of the schools using water, there are 19 public schools using 18.8 million gallons per year and 13 parochial schools using 6.0 million gallons for the same period. The total number of children of school age is estimated as 24 456. The school year extends over forty weeks, from the Friday following the second Wednesday in September, comprising about 210 actual school days.

The following table gives data on the consumption of water in the public schools of the city, the attendance being taken from the report of the Board of School Visitors of the City of Hartford for the year 1914.

District.	Total Average Attendance.			Total. Mil. Gal. per Year.	Gallons per Capita, Attendance per School Day.
	Scholars.	Teachers.	Total.		
Brown	1 589	47	1 636	2.66	7.75
South	4 182	144	4 326	3.52	3.88
Second North	1 380	54	1 434	1.25	3.74
West Middle	958	44	1 002	.86	2.61
Arsenal	1 514	58	1 572	.50	1.52 (min.)
Washington St.	1 177	45	1 222	.88	3.32
Southwest	243	13	256	.35	6.49
Northeast	1 211	46	1 257	1.63	6.68
High School	1 823	104	1 927	6.29	15.57 (max)
	14 077	555	14 632	17.94	5.84 (av.)

The average consumption per scholar in the public schools is 3.5 gal. per day per calendar year.

Miscellaneous Buildings. This use includes the Almshouse, City Hospital, House of Comfort, City Hall, Municipal Building, Halls of Record, Isolation Hospital, and a few minor consumers. By far the largest consumers are the Almshouse and City Hospital,

DISCUSSION.

George A. Johnson.* Mr. Saville has closed his interesting and instructive paper with some very pointed remarks anent check valves in dual systems of connections in distribution systems. In general the speaker agrees with him. Probably no piece of water-works equipment, with the possible exception of automatic control valves, has as warrantably acquired a man-size anathema as has the check valve on dual connections.

Reduced to its lowest terms, such things in a water distribution system mean that fire protection was the primary consideration. Not infrequently it happens that check valves are found on auxiliary connections to a pure water supply. Then, of course, there is no hygienic objection to them. More commonly, though, the auxiliary supplies are polluted, and it is the idea that they shall be used only in special cases, and a check valve is set against their mixture with the pure city supply. Theoretically this is all right, but if the check valves get out of order, as they have an unfortunate habit of doing, and bad water enters the city mains, causing an epidemic of typhoid fever, the past usefulness of the check valve is immediately and utterly discounted, for no commercial economy is measurable in terms of sickness and death.

Mr. Saville speaks of eternal vigilance as the price of success with check valves. That is true. Monthly or even daily inspection, however,, will not make a check entirely reliable. It may get out of order a few minutes after inspection and between that time and the next inspection, when the defect is found, do untold and immeasurable harm. Naturally the insurance people try their level best to make them reliable in operation, and safe, but a single check or a double check is liable to err.

A generation ago the check valve was considered a mighty useful appliance, but then we knew little of the dangers in impure water. It was only thirty-five years ago that the typhoid germ was discovered. To-day, however, we know a lot of things about the typhoid germ and typhoid fever and its causation, and, furthermore, through experience, it may be said that we are pretty well "onto" the check valve and its idiosyncracies. Where a

* Consulting Engineer, New York.

city has a dual system of water supply, one coming from polluted sources, — for fire protection, — and separated from the pure supply only by a check valve, one must conclude that such a city is taking big chances, for if "to err is human," erring on the part of the check valve seems to be a prominent feature in its makeup.

Finally, in the interests of the public health, the fire insurance underwriters ought to be as willing to gamble on the promptness of a watchman in opening a gate valve on an auxiliary line in times of emergency, as on a check valve which fails to act properly at the right time, or which is a greater menace to health than fire. Incidentally it may be added that in the United States in the last thirty years the vital capital dissipated by typhoid fever was over three times the net property loss from fire, so in questions like this, offering a choice between the loss of life and the loss of property, there should be no hesitancy in lining up on the side of health. The check valve, separating an impure auxiliary water supply from a pure city supply, is decidedly on the other side.

MR. R. C. P. COGGESHALL.* In New Bedford we have a number of the check valves which Mr. Saville has spoken of; in fact, we may have more than in any other place in the United States. We have at least 120. They are all put in on the basis that Mr. Saville has outlined. They are frequently inspected and careful note is made of each inspection, and I would say that at the present time they are working admirably, but their success depends upon vigilance. It is almost a necessity for us to have these valves in our city, because we haven't any dual supply as other cities have. Moreover, if any of these check valves should fail we would know it at once, because we would get salt water and not fresh water. The mill people would know it mighty quick, because they would get the salt water right in their plants if a check should fail. But we are looking after them all the time, for we believe there is no other safe way to do, and under our inspection they are working admirably.

MR. WILLIAM R. CONARD.† A number of years ago, when the methods were more or less by rule of thumb among the founders,

* Superintendent of Water Works, New Bedford, Mass.
† Burlington, N. J.

the causes for rejecting pipe were one thing, and as time has passed and the founders have improved their methods and have, at considerable expense to themselves, installed more scientific methods of procedure, the conditions and causes for rejection have also changed, due to the varying conditions under which the pipe are made. The present pipe specifications provide only for physical characteristics, and there was a time when that was sufficient to obtain the desired results, for the reason that the founders at that time were using practically all pure pig-iron with their own foundry scrap. By the use of analytical methods of determining what the mixtures are, they have found that they can meet the physical requirements of the specifications and can use a certain per cent. of outside or purchased scrap. The purchasers of cast-iron pipe have received the benefit of that use of outside scrap in reduced prices. In fact, the methods were adopted to meet the high competition that has been extant for a number of years in the pipe manufacturing business. The use of outside scrap, unless it may be large machinery scrap, makes the actual chemical properties of the mix a rather unknown quantity, and it is a question whether, in the use of pipe specifications, or the formulating of specifications for cast-iron pipe, it will not be necessary in the future to adopt some average condition of chemical components and insert it in the specifications, and also, if possible, limit by specification the amount of outside scrap that can be used. That, I may say, is a phase of specifications which is being considered by your present committee on pipe specifications.

MR. L. H. KUNHARDT.* Mr. Chairman, I would like to say a word. Of course those of you who know how I am connected in the fire protection work appreciate that I do believe in the double check valve; and the reason for it is because, as has been said here, it seems to furnish the only solution of the problem that we all have of making the public water supply serve its use for fire protection in the best way, that is, by putting the water directly at the seat of the fire. I know of nothing that can be done better than to give the automatic sprinkler the very best supply that you can. Some may say that a certain amount of water, a thou-

* Vice-President Manufacturers Mutual Insurance Company, Boston.

sand gallons a minute, is enough. It probably is in perhaps ninety-nine cases out of a hundred, but we are all of us constantly dealing with larger values, more concentrated values, and once in a while we have a case where we need all the water we can get hold of, — and then we wish we had a little more. If the pressure drops on the sprinkler equipment at any time, the fire gets under way and it is likely to destroy the building. Whenever a valve is shut on the sprinkler system, the result is the same.

I think you will find that in almost every case where there has been trouble from a pollution of the public water supply it has been due to a condition which antedates the real serious consideration of this problem of the double supply. Every case of which I have known, where there has been any leak back into the main, has been due to the imperfect arrangement of the old-fashioned system, with perhaps a single check valve buried in the ground; and also due in part to the condition which used to obtain in many cities and towns years ago, where the factory or mill had the best pumping equipment there was in the town, perhaps the only reliable high-pressure supply, and perhaps pumping from the river. The town system had a small reservoir and small pipe put in in the days when the community was much smaller than it is to-day. Now they have a fire and the supply isn't adequate; the fire gets away from them, and they appreciate the streams which can be supplied by the mill pumps, and if those streams cannot be brought to bear from where the mill is situated, they will pump through the town mains. They have even gone so far as to ask the mill to arrange a by-pass around the check valves, so they can bring the water to the fire.

We approve the double check valve with a view of making as safe and as perfect an arrangement as can be designed; and then, in order to make it as secure as possible, we put them in pairs, so that if one should happen to leak a little, the other one will serve its purpose. And we have arranged them all in vaults, so they can be easily inspected and cared for. Mr. Coggeshall said they were working admirably, and Mr. Saville said that they seemed to furnish the best solution of the problem where it is necessary to have a double supply. Our experience with them has been eminently satisfactory. We have studied the problem from both

sides, and it seems to me that there is nothing better which at present can be offered to manufacturers and large mercantile establishments to afford the protection which they need all the time, and which is essential if the public water supply for any reason is cut down in pressure, or if it is shut off in the street where the fire occurs and where the sprinkler connection is taken.

MR. H. O. LACOUNT.* This paper is of particular interest to fire protection engineers, and there is one point in reference to check valves in which I am personally very much interested which was not touched upon by Mr. Kunhardt, and I do not think was referred to by Mr. Saville, and that is the great value of fire protection in industrial plants, not only for the large property values, but also for the human life. Now I should like to put on record here the statement that in the approximately three thousand mills, scattered all over this country, insured in the Mutual Companies, and which are largely under sprinkler protection, during thirty-five years only five lives have been lost by fire; and those factories are occupied every day by about a million and a half of people. That seems to me to phenomenal record, a very wonderful record, in a sense, and it is an incentive to every one having to do with the fire protection system to give it the very best possible water supply, in order that the good work may not be hindered, but may go on. So when one speaks of the matter of the health of the community in connection with the pollution of the city water supply, I think there are two sides to the question, and I think the maintaining of these two supplies for fire protection is also in the line of saving life.

By the way, as a further record, there are about one hundred and fifty of these connections now in the country, of which we have knowledge, equipped with these double checks. In other words, there are about three hundred single checks installed in pairs. And the record of those checks is still good, after six or seven years of experience. Mr. Saville, in his characteristically vigorous manner, has condemned the dual system, but he also is fair to the double check system in that where the dual system is, or for any reason is considered to be, the best solution of the necessities of the case, this double check does answer the purpose better than any other thing that has yet been put before us. Credit to whom credit is due.

* Engineer, Associated Factory Mutual Fire Insurance Companies, Somerville, Mass.

There is one other thing on which perhaps Mr. Saville thought that if I got the floor I would lock horns with him from the fire protection standpoint, and that is the throttling of gates. But I am not disposed to do that, but I simply want to put in this caution, — that when the necessity becomes apparently urgent we don't do it unless we know, not from paper figures, but from a demonstration and a test, that we haven't throttled them at any point so that we can't supply from fifty sprinklers, say, approximately one thousand gallons a minute without a serious loss of pressure, — in other words, without dropping the pressure to a non-useful point, so far as the sprinkler system is concerned.

THE MIDDLEBORO, MASS., REINFORCED CONCRETE WATER TOWER TANK.

BY GEORGE A. SAMPSON.*

[*Read December 8, 1915.*]

The town of Middleboro is situated in Plymouth County, Massachusetts, and like many other places in the southeastern part of the state, and elsewhere, has no favorable site for a storage reservoir or standpipe for a gravity fire supply. The highest point of land in Middleboro, or within fifteen miles roundabout, is Barden Hill, about 4 600 ft. southeast of the business center of the town, with an elevation of only 35 ft. above a considerable part of the residential district and about 175 ft. above sea-level.

This fact, together with the following brief description of the Middleboro Water Works, will aid in an understanding of the conditions which led up to the construction of the present concrete tower tank.

The works were built in 1885 by the Middleboro Fire District. The source of supply is a large dug well 26 ft. in diameter and 22 ft. deep, located about a mile southeast of the center of the town and 60 ft. from the east bank of the Nemasket River, and fed for the most part from the gravelly hills and tableland to the east. A brick pumping station was erected nearby, equipped with two Deane, compound, condensing, duplex pumping engines, each of 600 gal. per minute capacity, against a head of 200 ft., discharging through a 10-in. force main into the distribution system supplying the district. A wrought-iron standpipe 20 ft. in diameter by 103 ft. in total height, with a capacity of about 235 000 gals., was erected in a residential section of the town, the highest available location on the west side of the river, giving, when filled to overflowing, a static hydrant pressure at the business center of 63 lbs., often reduced to 56 lbs. or less under ordinary conditions of draft, and still further decreased by the friction

* Of Weston & Sampson, Consulting Engineers, Boston.

in the mains and hydrant. This pressure was sufficient for domestic uses but inadequate for fire protection, especially in view of the increased pressure standards generally recognized as desirable.

To relieve this condition, an electrically operated valve, controlled by a switch at the pumping station, was installed during 1908 in the pressure main at the base of the standpipe; and a relief valve was placed on the discharge from the pumps set to blow-off at about 115 lbs. at the station, which corresponds to a static pressure of 95 lbs. in the business section. Upon the sounding of a fire alarm, the electric valve was closed and direct pumping into the mains with both pumps depended upon for the requisite quantity of water and the desired pressure. At the same time, the capacity of the two pumps was increased, by boring out the pump cylinders, from 1 200 to 1 600 gals. per minute, which, with an allowance for ordinary domestic uses, furnished from four to six good fire streams.

Then came the eight-hour laws in Massachusetts which, in order to insure a ready-to-serve fire supply, necessitated the employment of six men at the pumping station, three of whom must be licensed engineers, — an expense out of all proportion to the size of the plant. Add to the above considerations the fact that the standpipe had been in service for thirty years; that a careful inspection in 1911 revealed an altogether too narrow margin of safety, and another in 1913 showed a still more urgent need of its immediate discontinuance, and you can imagine the conditions that recently confronted the water commissioners, of whom Mr. Alvin C. Howes, a member of this Association, is chairman and superintendent of the water works.

After several Fire District meetings and much discussion, it was voted, in February last, to construct on Barden Hill a standpipe of 500 000 gal. capacity, and the commissioners engaged the writer to design and supervise the construction of the proposed structure. The problem presented was the storing of half a million gallons of water at an elevation sufficient to meet the combined demands of domestic and fire services. The most economical type of structure fulfilling the requirements was a tower tank, an elevated tank supported on a tower, sometimes

called a water-tower, and the only practicable materials for building such a structure were steel and reinforced concrete. A steel tower tank was estimated to cost about \$2 000 less than one of concrete, but the cost and inconvenience of frequent painting inside and outside, a safe life of not over thirty years, its unsightly appearance, and other considerations made it apparent that if a satisfactorily watertight concrete tank could be constructed it was greatly to be preferred. The difficulties, however, of designing and building such a structure, especially of the proportions

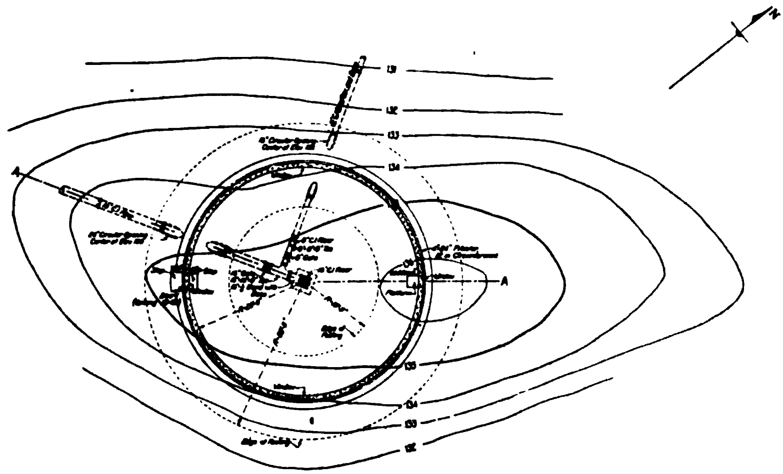


Fig. 1.

required, were many and vital. Its success or failure, perhaps more than in any other engineering work, depends to a large degree upon each individual connected with the work from the time the concrete materials are selected until they are finally deposited between the forms to become a monolith of artificial stone. With due regard for the difficulties involved, it was nevertheless decided in favor of a concrete structure.

Plans and specifications were prepared, and bids from seven contractors were opened on April 6. The lowest of these bidders was the Hennebique Construction Company of New York City, to whom the contract was awarded on April 12 for the sum of

$23 140. Mr. Thomas F. Dorsey was engaged by the writer as resident engineer in direct charge of the work.

FOUNDATION.

The foundation extends 7 ft. below the finished grade and rests upon a fine, well-compacted sand, the safe bearing power of which was determined experimentally by loading a timber set at the elevation of the bottom of the foundation. At a loading of from 1 to $3\frac{1}{2}$ tons per square foot, the settlement was uniform and slight, being only $\frac{1}{32}$ in. for each additional $\frac{1}{2}$ ton; but 4 tons per square foot produced a relatively large settlement — $\frac{5}{32}$ in. for the last $\frac{1}{2}$ ton. The footing area is such that with the total dead weight of 4 485 tons the soil is compressed to the extent of 2.28 tons per square foot. The wind load was computed from an assumed velocity of 70 miles per hour, the equivalent of 30 lbs. per square foot on a vertical projection of the structure, which with a full tank adds a maximum of 0.68 tons, thereby giving a total maximum pressure of 2.96 tons per square foot. Although the resultant of the wind pressure is slightly more than doubled with an empty tank, it is more than offset by the reduction in the dead weight of the water, so that the maximum mentioned represents the worst condition.

TOWER.

A cylindrical tower was adopted in preference to a number of columns, because structurally it seemed a safer type of support, would probably be more economical to construct, and could be made to present a more pleasing appearance. Considerable study was given to the architectural side of the problem in order to produce at a moderate cost a structure that would be, to some extent at least, an addition to the landscape. The plain aspect of a simple cylinder is relieved by the addition of twelve 4- by 24-in. pilasters, which were assumed to take their proportion of the load. The appearance of solidity at the bottom is accomplished by a concrete seat extending around the base of the tower. A balcony of reinforced concrete with bracket supports, paneled posts and railing, the floor of which is 108 ft. above the ground, furnishes a

FIG. 1.

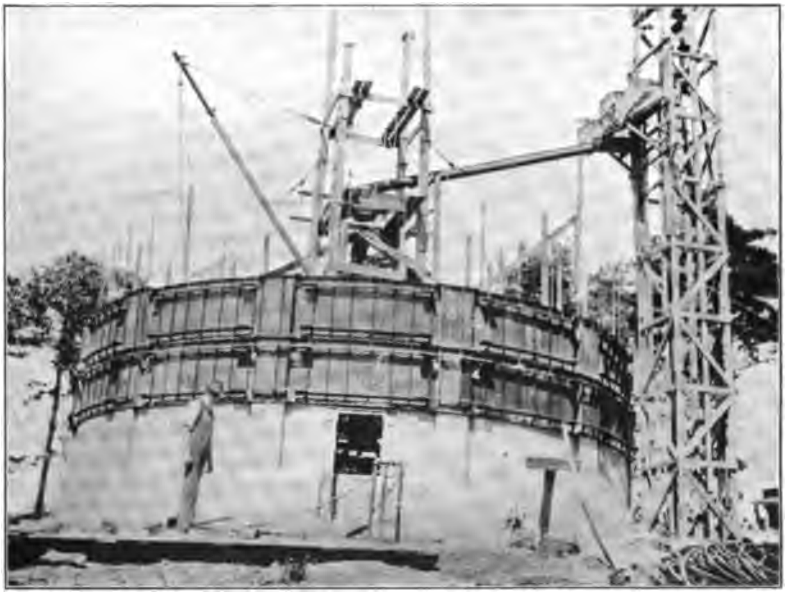


FIG. 2.

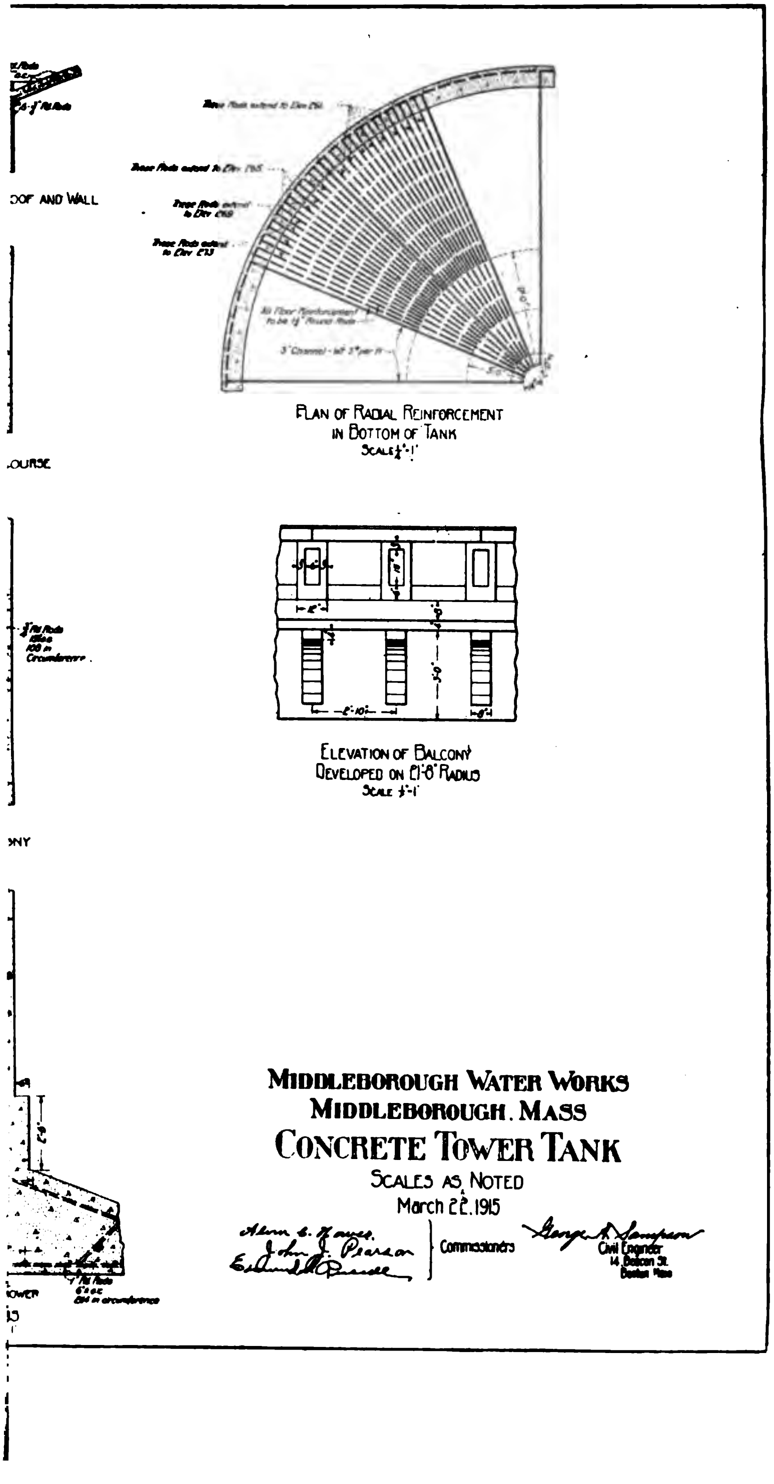

Plan of Radial Reinforcement
in Bottom of Tank
Elevation of Balcony
Developed on 21'-8" Radius
Middleborough Water Works
Middleborough, Mass
Concrete Tower Tank
Scales as Noted
March 22, 1915
Commissioners
Civil Engineer
14 Beacon St.
Boston Mass

FIG. 1.

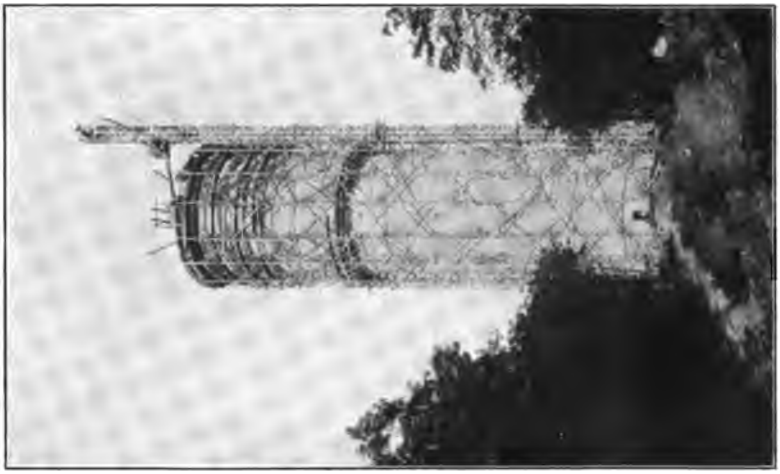


FIG. 2.

suitable point of vantage for inspecting the outside of the tank, and provides a visual starting point for the tank proper. The thickness of the tower wall between pilasters is 10 ins. and the greatest compression due to the dead load is 483 lbs. per square inch, increased to 631 lbs. by a 70-mile gale. Entrance to the tower is through an iron door. Light and ventilation are provided for by means of twelve windows, three of which are arranged to open. An iron ladder within the tower leads from the ground to the balcony through an opening in the wall of the tower at the elevation of the balcony floor. Another iron ladder on the outside of the tank connects the balcony with the roof above. A 16-in. cast-iron flanged pipe with expansion joint rises from the ground and enters the tank at its center. An 8-in. overflow and drain discharges at a safe distance from the tower.

Tank.

The tank proper, 41 ft. in inside diameter and having a depth of water at its center of 59 ft., has a capacity of slightly over half a million gallons. The bottom of the tank is a hemispherical bowl hung at its rim from the wall of the tower, and marks the first application of this type of bottom to an elevated concrete tank, although for many years it has been used with success in elevated steel tanks. The bowl itself has a capacity of 125 000 gals. The vertical wall of the tank varies in thickness from 10 ins. at the top to 16 ins. at the bottom, and the hemispherical bowl from 18 ins. at its connection with the tank wall to 14 ins. at its center. The thickness of concrete is such that without any assistance from the steel reinforcement its stress in tension is about 250 lbs. per square inch. The tensile stress in the steel acting independently is approximately 14 000 lbs. per square inch; and with both materials acting in conjunction the computed stresses are 215 and 2 150 lbs. The tank is covered to guard against the growth of algæ, not uncommon in a filtered water supply exposed to light, and to prevent freezing. The roof is a concrete dome 4 ins. thick, 41 ft. in diameter, and with a rise of 4 ft. at the center. The thrust is carried by steel reinforcement embedded in the top of the tank wall.

CONCRETE.

Whitehall cement from the Whitehall Portland Cement Company's mill at Cementon, Pa., was used throughout the work. Sampling and testing was done by the New England Bureau of Tests, of Boston, samples being taken as loaded on the cars, which were then sealed. The tests of the twelve carloads required, aggregating 8 100 bags, were unusually uniform and satisfactory, especially for the essential qualities of strength, fineness of grinding, and slow initial set. The sand and coarse aggregate were obtained from a gravel pit about 1¼ miles distant, screened by hand at the pit to give the sizes required. The sand was tested for tensile strength as compared with standard Ottawa sand and gave an average of 112½ per cent. thereof. The gravel stones were washed to remove a slight coating of clay and cemented sand. The proportions of the concrete for the foundation are 1 of cement, 2½ of sand, and 5 of gravel stone; for the tower, 1 : 2 : 4; for the hemispherical bottom and wall of the tank to elevation 279, 1 : 1 : 2; from elevation 279 to 293, 1 : 1½ : 3; and above elevation 293, including the dome roof, 1 : 2 : 4. The relative amounts of sand and stone were somewhat varied to provide the densest practical mix, the percentage of cement to the sum of the aggregates, however, remaining as stated. The amount of concrete used in the work was 1 120 cu. yds.

STEEL REINFORCEMENT.

"Havemeyer," round, deformed, open hearth, hard grade reinforcing rods furnished by the Concrete Steel Company of New York, and bent at the rolling mills, were used in the structure. These were tested at the Carnegie mills by the New England Bureau of Tests, a large proportion of which were 1¼-in. and developed an ultimate tensile strength of 120 000 lbs. per rod. Laps were 40 diameters, and in addition each joint in the tank was secured by two cable clips. The horizontal rods of the tank were firmly secured in their true position to sixteen vertical 3-in. channels drilled to the exact spacing of the rods. One hundred and sixty thousand pounds of steel reinforcement were embedded in the concrete.

Forms.

Steel forms made by the Blaw Steel Construction Company of New York were used for the outside surface of the tower and tank. Two complete rings were provided, each 4 ft. in height, at a total cost of $600. Two 4-ft. rings of wooden forms were used on the inside at a first cost of $400. The use of steel forms was justified both on account of a considerable saving in time and expense in erection and because of the resulting smooth, dense surface, requiring very little finishing and less susceptible to the action of the elements. The hemispherical bottom was cast between forms consisting of wooden ribs covered with sheet iron.

Joint between Old and New Concrete.

For the tower, in order to secure a bond between the successive rings of concrete, the forms were overfilled about $\frac{1}{4}$ in., which surplus containing the laitance was screeded off previous to the initial set of the concrete, following which as soon as the final set occurred the surface was wire-brushed to slightly expose the stones and, immediately before placing fresh concrete, washed with a hose stream and coated with a neat cement grout. For the tank, in addition to the above precautions which were carried out with especial care, there was cast in the old concrete a continuous triangular groove, about $1\frac{1}{2}$ in. in depth, running around the wall near its center and subsequently filled with grout and concrete; to still further minimize the chances of leakage, at each horizontal joint an uncoated steel plate or dam of No. 14 gage metal 10 ins. wide, turned over one inch at each edge to form a channel, and bolted together to form a continuous watertight stop, was embedded 4 ins. into the old work, thus leaving 4 ins. extending up for a bond with the new concrete. The cost of twelve channel rings in place was about $400.

Progress of Work.

Ground for the foundation was broken on April 26. After the excavation was completed the earth was wetted and thoroughly compacted by rammers, following which a 2-in. layer of concrete was placed over the entire surface to serve as a working base for

the erection of the steel reinforcement and as a suitable medium upon which to place concrete. All concrete was mixed in a 15 cu. ft. Smith mixer operated by steam and discharging into a bucket elevator which at the desired height was tripped and dumped into a receiving hopper, whence it was conveyed by gravity through a sheet steel chute to a central distributing hopper, and finally by means of eight movable wooden chutes was deposited between the forms around the circumference.

The concrete materials were brought to the mixer in dump cars running on an inclined industrial railway and pulled up the incline by a cable attached to a drum of the hoisting engine. The average rate of progress on the tower was a 4-ft. ring each alternate day, with a marked increase in efficiency as the work advanced. The actual time required for concreting was about four hours to each 4-ft. section. The bottom of the tank, including four feet of the wall immediately above the tower, was poured continuously. Concreting began at 5 A.M. on September 9, and the last batch was deposited at 4 A.M. the following day, during which time about 130 cu. yds. of 1 : 1 : 2 concrete were placed. Five days elapsed before the following section was in place and two more days before the succeeding ring was concreted. Four days were then spent in preparing for future operations, so that when concreting began again on the fifth day the following eight successive lifts were made in nine days, and it was only due to a violent gale of about seventy miles per hour that operations had to be suspended for one day. The roof of the tank was poured on October 13.

WATERTIGHTNESS.

As soon as the forms were removed from the inside of the tank and the staging from around the outside, the surfaces were cleaned and so far have received no further treatment, although after the tank has been fully tested and accepted as satisfactorily water-tight, the question of waterproofing the inside and damp-proofing the outside surface will be considered. Coincident with the removal of the outside staging around the tower, the surface was cleaned and washed with a brush coat of neat cement grout, mixed in the proportion of one of cement to one of water. The

cost of cleaning and coating the 14 000 sq. ft. of surface was \$75.00, or about 0.54 cent per square foot. In connection with the subject of watertightness, the following clause from the specifications may be of interest:

"The concrete in the bottom and wall of the tank shall be substantially watertight at all times. Any leakage amounting to jets or visible seepage shall be repaired by and at the expense of the contractor and by methods approved by the engineer. Small damp spots, if few in number, which do not increase nor disfigure the appearance of the concrete, will be considered to meet the requirements hereunder. It is intended that the work shall be sufficiently waterproof that severe freezing will not at any future time threaten the integrity of the concrete and that the general appearance of the structure will not suffer through efflorescence or other disfiguring stains."

The work, including grading and cleaning up, will be completed this week, and it is hoped that water may be turned into the mains to supply the District on January 1. The static hydrant pressure with a full tank will be 84 lbs. in the higher residential area, 104 lbs. in the business center, and 120 lbs. in the low district along the Nemasket River, reduced by about 20 lbs. by frictional losses during an ordinary fire. For the year 1914 the population supplied with water was 5 000 and the average daily consumption 320 000 gals., so that a thirty-six hours' supply of water is available, every drop of which is of value.

REVENUE AND OPERATING EXPENSE OF MUNICIPALLY OWNED WATER-WORKS IN MASSACHUSETTS FOR THE YEAR 1913.

BY CHARLES W. SHERMAN.*

There has recently appeared from the State Bureau of Statistics the Eighth Annual Report on the Statistics of Municipal Finances covering the year 1913 (that is, fiscal years ending between November 30, 1913, and April 1, 1914). This report contains in considerable detail the figures indicating the financial transactions of all the cities and towns in the Commonwealth. Those for water-works systems are not grouped by themselves but are given in the general tabulations under the heading "Public Service Enterprises." The gross amounts contained in these tables are of little significance in themselves and cannot readily be compared with those of other cities and towns, except those appearing on the adjoining pages of the report.

In order to obtain really significant data from these figures, the writer has abstracted the figures of revenue and operating expense for all the cities and towns having municipal water works and has computed the per capita revenue and expenses, using population estimated on the basis of the 1910 and 1915 census figures. The results are given in the three tables accompanying, where Table 1 contains the statistics of the thirty-six cities; Table 2, those of the fifty-two towns having a population of 5 000 or over; and Table 3, those of the forty-seven towns having a population of less than 5 000.

It should be noted that in substantially if not absolutely all cases, the figures reported are based on cash receipts and expenditures and not necessarily on the true earnings and expenses for the year under consideration. It is also to be remembered in comparing these figures with similar figures for privately owned water-

NOTE.—This paper has not been read at any meeting. Discussion is invited for future publication.

* Of Metcalf & Eddy, Consulting Engineers, Boston.

works systems that in but few of the municipally owned plants does the water works receive any revenue for fire protection or hydrant service, and that in no case except Holyoke does the water department pay taxes. It must also be borne in mind that in a very large number of cases, particularly in the small towns, the administrative machinery of the town is utilized for the benefit of the water works without compensation out of water revenue, — thus town treasurers or collectors of taxes in a great many cases render and collect the bills for water, the office and possibly the shop of the water department is in the town hall, and it may be in some cases that one of the selectmen or some other town officer acts as superintendent without additional compensation, or, at most, with very slight compensation from the water department.

Tables 1 and 2, relating to the cities and the larger towns, represent long-established water-works systems in which the development is substantially complete. That is to say, the water pipes reach substantially all parts of the communities and the number of people not supplied from the public works is insignificant. In the case of the smaller towns listed in Table 3, however, the conditions are very different in many cases. Oftentimes these works supply only the thickly settled central portion of the town, while a considerable portion of the population living in outlying districts is not reached by the water works. In such cases per capita figures, based on the entire population, are obviously of comparatively slight significance and should be used with great caution. In other cases the works have been recently established and have not yet reached their full development, even in the districts supplied. In a few cases of summer resort communities the revenue and expenses are abnormally large for the permanent population and ought more properly to be based on the maximum or transient population, if trustworthy figures were available.

In the case of cities and towns in the Metropolitan Water District, it should be noted that the operating expense includes only so much of the Metropolitan assessment as relates to maintenance of the Metropolitan Water Works.

For the reasons set forth above, the averages for Table 3 are probably not of great significance. Those of Tables 1 and 2 are, however, probably fair indications of the per capita revenue and

operating expenses to be expected of thoroughly developed municipal water works in this state. Local conditions, of course, have a very considerable effect, particularly upon the operating expense; and the extent to which funded debts have been retired and the amount of extensions to be paid for out of earnings in addition to meeting operating expense would largely affect the amount which should be assessed in gross revenue.

It is hoped that water commissioners and superintendents will find these figures of assistance, particularly in making it possible to compare the conditions in the works under their charge with those of other cities and towns where the conditions are more or less similar.

DISCUSSION.

MR. CHARLES F. GETTEMY.* I am sure I voice the sentiments of my assistant, Mr. Waddell, who is here with me this afternoon, as well as my own, in expressing to you, Mr. President, and to Mr. Sherman, who is responsible, I presume, for our presence here, our great appreciation of the opportunity which you have given us to get away from our desks and some of our routine duties in order to come here and meet this intelligent body of scientific men. It is a great privilege to be able to come in contact with such a body and have the opportunity to listen to these interesting papers that have been read.

The hour is so late that it does not seem to me that this is perhaps the time to say anything that might lead to an extensive discussion of the very important matter which has been raised by Mr. Sherman in his interesting and certainly suggestive paper. It is, nevertheless, an exceedingly important point that has been raised as to whether our present municipal indebtedness laws should be amended along the lines suggested, and I hope you will believe me when I say that we have absolutely no pride of opinion in regard to these matters, and that we are only anxious to see the municipal indebtedness laws of Massachusetts in such form as will make for sound management of municipal finances, as well as drawn in such a way as not seriously to affect the convenience and well-being and health of the people who compose our municipalities.

* Director State Bureau of Statistics, Boston.

TABLE 1.

GROSS WATER-WORKS REVENUE AND OPERATING EXPENSE PER CAPITA IN MASSACHUSETTS CITIES FOR THE YEAR 1913.

Number.	City.	Population.	Gross Revenue per Capita.	Operating Expense per Capita.
1	Boston	721 700	$4.08	$1.43
2	Worcester	156 012	2.86	0.60
3	Fall River	122 592	1.86	0.63
4	Lowell	107 405	1.82	1.31
5	Cambridge	107 230	3.57	1.12
6	New Bedford	104 400	2.66	0.81
7	Springfield	97 353	3.69	2.01
8	Lynn	93 215	3.34	1.64
9	Lawrence	88 511	1.53	0.71
10	Somerville	83 000	2.79	0.73
11	Brockton	60 124	2.45	0.91
12	Holyoke	59 580	2.16	1.66
13	Haverhill	47 316	2.72	0.85
14	Malden	46 500	2.27	0.73
15	Newton	41 789	3.42	0.96
16	Salem	39 800	3.05	1.27
17	Chelsea	39 037	3.20	0.67
18	Fitchburg	38 922	2.15	1.28
19	Quincy	37 460	3.26	0.68
20	Pittsfield	36 612	3.24	0.57
21	Everett	36 025	3.15	0.78
22	Taunton	35 399	2.67	1.26
23	Waltham	29 226	3.15	1.53
24	Chicopee	28 242	2.35	0.97
25	Medford	27 566	2.45	0.52
26	Gloucester	24 446	4.45	1.21
27	Revere	23 289	3.16	0.79
28	North Adams	22 028	2.79	0.41
29	Beverly	21 236	3.36	1.66
30	Northampton	20 766	2.95	0.96
31	Leominster	17 619	3.50	0.68
32	Attleboro	17 574	3.84	1.05
33	Melrose	16 411	2.72	1.13
34	Woburn	15 968	3.29	1.12
35	Newburyport	15 165	4.10	1.41
36	Marlborough	14 981	3.03	0.77
Average		69 290	3.16	1.14
Maximum			4.10	1.66
Minimum			1.53	0.41

Ratio of average operating expense to gross revenue = 36 per cent.

TABLE 2.

GROSS WATER-WORKS REVENUE AND OPERATING EXPENSE PER CAPITA IN MASSACHUSETTS TOWNS OVER 5 000 POPULATION FOR THE YEAR 1913.

Number.	City.	Population.	Gross Revenue per Capita.	Operating Expense per Capita.
1	Brookline	31 312	$3.47	$1.40
2	Peabody	17 464	5.60	1.59
3	Westfield	17 463	2.76	0.50
4	Gardner	15 704	3.97	1.14
5	Watertown	15 059	4.02	0.60
6	Framingham	14 694	4.52	1.31
7	Weymouth	13 540	3.66	0.85
8	Arlington	13 407	4.37	1.48
9	Clinton	13 144	2.58	0.80
10	Methuen	12 984	2.35	0.82
11	Plymouth	12 612	2.92	1.02
12	Wakefield	12 229	3.17	1.53
13	Webster	12 142	1.92	0.70
14	Winthrop	11 707	4.88	1.95
15	Natick	10 619	2.61	1.30
16	West Springfield	10 493	4.70	1.94
17	Danvers	10 469	3.69	0.94
18	Winchester	9 726	4.00	2.28
19	North Attleboro	9 463	2.94	1.28
20	Saugus	9 355	1.49	0.78
21	Easthampton	9 316	1.92	1.08
22	Athol	9 283	4.35	0.95
23	Norwood	9 193	3.63	1.36
24	Ware	9 116	1.33	0.97
25	Amesbury	9 084	3.75	1.05
26	Braintree	8 831	4.34	1.94
27	Milton	8 329	6.08	2.66
28	Andover	7 706	2.96	1.13
29	Marblehead	7 500	4.41	1.59
30	Whitman	7 430	2.54	1.39
31	Stoneham	7 330	3.20	1.29
32	Belmont	7 282	3.55	0.82
33	Rockland	7 015	2.94	1.91
34	Swampscott	6 888	5.90	2.31
35	Hudson	6 752	2.26	0.29
36	Stoughton	6 715	2.31	0.86
37	Maynard	6 618	2.04	0.68
38	Concord	6 577	4.45	1.54
39	Reading	6 409	3.78	1.55
40	Spencer	6 293	1.86	0.30

TABLE 2. — *Continued.*

Number.	City.	Population.	Gross Revenue per Capita.	Operating Expense per Capita.
41	Franklin	6 121	$2.95	$0.90
42	Ipswich	6 074	2.45	0.82.
43	Wellesley	6 028	4.94	1.80
44	Needham	5 935	2.89	1.29
45	Winchendon	5 816	2.53	0.89
46	North Andover	5 784	2.07	1.12
47	Westboro	5 734	1.94	0.74
48	Abington	5 569	3.18	1.57
49	Orange	5 340	2.69	0.93
50	Canton	5 292	2.94	1.85
51	Lexington	5 290	5.00	1.26
52	Walpole	5 252	3.93	2.15
Average		9 529	3.43	1.24
Maximum			6.08	2.66
Minimum			1.33	0.29

Ratio of average operating expense to gross revenue = 36 per cent.

TABLE 3.

GROSS WATER-WORKS REVENUE AND OPERATING EXPENSE PER CAPITA IN MASSACHUSETTS TOWNS UNDER 5 000 POPULATION FOR THE YEAR 1913.

Number.	City.	Population.	Gross Revenue per Capita.	Operating Expense per Capita.
1	Monson	4 905	$1.40	$0.32
2	Uxbridge	4 821	2.77	1.24
3	Randolph	4 562	2.38	1.09
4	Dudley	4 330	2.07	0.72
5	Provincetown	4 324	2.25	1.12
6	Rockport	4 295	3.85	2.39
7	Agawam	4 134	0.58	0.36
8	Templeton	3 951	1.72	1.33
9	Falmouth	3 609	7.66	2.73
10	East Bridgewater	3 558	1.40	0.48
11	Barre	3 269	1.18	0.24
12	Billerica	3 062	2.47	1.56
13	North Brookfield	2 997	2.52	1.36
14	Holbrook	2 894	3.52	1.48
15	Pepperell	2 884	3.20	1.24
16	Manchester	2 835	6.47	4.70
17	Ayer	2 789	3.18	1.28

TABLE 3. — *Continued.*

Number.	City.	Population.	Gross Revenue per Capita.	Operating Expense per Capita.
18	Medway	2 786	$2.45	$0.69
19	West Bridgewater	2 537	3.24	0.69
20	Lancaster	2 536	3.72	2.55
21	Kingston	2 526	2.45	0.96
22	Hopkinton	2 467	1.38	1.19
23	Sharon	2 406	3.96	1.36
24	Hatfield	2 387	1.92	0.17
25	Holden	2 366	1.90	0.08
26	Douglas	2 167	1.02	0.74
27	Wrentham	2 145	2.46	1.04
28	Merrimac	2 142	2.55	1.51
29	Williamsburg	2 123	1.52	0.48
30	Brookfield	2 117	1.10	0.60
31	Avon	2 103	2.33	1.43
32	Wayland	2 101	1.40	0.78
33	Ashburnham	2 077	1.70	1.65
34	Ashland	1 877	2.50	1.19
35	Rutland	1 833	2.19	1.11
36	Northboro	1 764	2.86	0.70
37	Longmeadow	1 504	3.05	2.04
38	Marion	1 475	5.66	3.35
39	Millis	1 426	2.36	1.27
40	Plainville	1 400	1.65	1.22
41	Bedford	1 312	2.70	0.92
42	Nahant	1 307	8.85	4.40
43	Mattapoisett	1 305	1.68	1.30
44	Tisbury	1 274	10.40	5.70
45	Lincoln	1 256	9.72	3.60
46	Littleton	1 229	2.50	1.32
47	Russell	1 049	1.38	1.52
Average		2 556	2.80	1.34
Maximum			10.40	5.70
Minimum			0.58	0.08

Ratio of average operating expense to gross revenue = 48 per cent.

I am frank to say, however, that the matter is, in my opinion, of sufficient importance to warrant the legislature in giving very careful consideration to the question as to whether these laws should be amended. This particular proposition is so bound up with the whole subject of municipal indebtedness that I confess

it is difficult for us to divorce and isolate altogether water debt from other municipal debt; and, if you will allow me, I should like simply to content myself on this occasion with merely throwing out a few suggestions which possibly may throw a little light on the present legislation and the laws relating to the subject.

I think I am justified in saying that if, as has been suggested, the extension of the construction of water-works systems has been seriously interrupted in the last two or three years by virtue of the existence of this legislation which has been referred to on the statute book, resulting in a decrease in the amount of water-works construction and a discouragement of extensions, and a slowing down of the rate of progress at which such extensions were being made prior to the passage of this legislation, it has been due not so much to the fact that this is new legislation which has supplanted old legislation, but to the fact that for the first time laws which are from thirty to forty years old, as matter of fact, are now being more generally observed and enforced; and that if a greater rate of progress was being made formerly, it was not because that sort of thing was permitted under the laws as they stood prior to 1913, but because those laws were not enforced, and, if not directly evaded by our municipalities, were, at any rate, subjected to most elastic and loose interpretation. One, of course, always trenches on delicate and dangerous ground when he undertakes to say a given statute is being violated. That in the last analysis, of course, is a matter for the courts to determine. So, possibly, I had better say that the laws prior to the passage of the general municipal indebtedness act of 1913 regarding the amortization of municipal indebtedness by the serial method, so-called, were so loosely drawn that there was opportunity for a difference of opinion with regard to their construction. It may, therefore, be useful to the members of your organization, in the event that you think that an amendment of the present legislation ought to be sought, if I take up your time just for a few moments in giving you an outline of the facts that led up to the passage of this legislation.

It dates back to the preliminary investigation made by the Bureau of Statistics during the winter of 1911, when a bill was introduced into the legislature for refunding a demand note of one

of our towns that had been outstanding then about thirty-five years; and it appeared that although that note was bearing six per cent. interest, having been issued in 1875, the town was continuing to pay this rate of interest and would have done so indefinitely; and although it might be regarded as a pretty good permanent investment, it so happened that it was held by a board of trustees which for some reason wanted to turn it over, and when they walked into the town treasurer's office with the note and demanded the money, of course the town treasurer didn't have it and so the town had to come to the legislature and ask to have the debt refunded. That opened the eyes of a certain member of the Senate, who was curious enough to wish to ascertain to what extent our cities and towns had debts of that sort. So he introduced an order in the Senate asking the Director of the Bureau of Statistics to cause an inquiry to be made, — and incidentally requiring the report to be made in two weeks; sometimes when they get started on Beacon Hill they want to hurry things up pretty fast, — and to report the amount of outstanding indebtedness in our cities and towns for the payment of which no provision had been made.

We did the best we could with such data as we had on file in our office and made a report; and it disclosed such a condition of affairs that I am frank to say that those of us who felt some responsibility in regard to the matter were fearful that the legislature would be so influenced by that report that it might result in the passage of prematurely digested legislation. We wished to avoid that, and we frankly confessed that we had merely skimmed the surface of the subject and requested an opportunity to make a more thorough investigation, which request the legislature granted and authorized the department to make a complete investigation of the whole subject of municipal indebtedness in Massachusetts. They placed sufficient funds at my disposal to do that, and I sent agents into every city and town, and the following year was able to make the first complete presentation of facts in regard to the municipal debts of the Commonwealth which had ever been made. The order calling for the investigation incidentally provided that such recommendations for legislation as might seem desirable should be made.

We found in the course of the investigation that the Municipal Indebtedness Act, which had been placed on the statute books first in 1875, — up to that time there was absolutely no legislation, so far as we could find, governing this subject at all, — in the lapse of thirty-five years had very largely become a dead letter. The number of ways which our municipalities had devised to evade its provisions were extremely ingenious, and we found that some towns were issuing bonds or long-term notes for all sorts of things, such as the purchase of a town hearse in one small town; in another case, to publish a town history; and the other instances where debt was created for purely current expenses, such as the payment of school teachers' salaries and so forth, are too numerous to mention. There wasn't any doubt but that under the old law the incurrence of debt for current expenses was permissible for a period of ten years, — that is, permissible in the sense that it was legal, — and that was one of the great problems that confronted us in trying to draw a law which would put a stop to that practice.

The result was that we took the law as it stood on the statute books and revamped it and provided twelve or fifteen specific objects for which municipalities could borrow money. As no one could be found who could define the term "current expenses," it would be absolutely useless simply to pass a law prohibiting the creating of a debt for current expenses. The only way that problem could be met was by selecting those purposes which every one agreed would be proper objects for incurring municipal debt and authorize the borrowing for those purposes and then absolutely prohibit the borrowing for any other purpose.

The periods for which the loans should run were fixed so as to agree with the life of the object for which the loans were to be secured. As far as water districts are concerned, I don't think any change was made in the statute.

Regarding the method of amortizing debt, under the old statute the cities and towns were allowed the option of establishing sinking funds. In the original Municipal Indebtedness Act of 1875 sinking funds were the only method recognized; the serial method at that time was hardly known. In 1882 the legislature passed what was called the Serial Loan Act, which gave municipalities the option of issuing their debt by the serial method; and in the

course of time that has become more and more popular and finally reached the point where it is so generally recognized as the proper method of paying off debt that one very important provision of this new act was a clause which absolutely prohibited the further establishment of sinking funds by municipalities and required that payment be made by the serial method.

The serial method of paying the debt had been provided for in the old statute, but it was very loosely worded and it apparently didn't mean anything to our municipalities, especially to the towns, because they fixed their own interpretation upon it; and we found that a very popular method of interpreting the law was to provide that very small payments should be made at the beginning of the term and should gradually increase, postponing the burden to the next generation; and we found evidences of what we called, for lack of a better term, " ragged " serials. They would start to pay a portion next year and another portion the following year, and then they would skip from one to five years before they would begin to pay again. And so it became necessary to define with some exactness the term " serial," and that is the only respect in which the new statute can be said to supplant the old with reference to this matter. The new law merely defined the meaning of the word " serial ' without in any other way, I think, really affecting the original statute.

At the time that we made our report to the legislature we were confronted with the fact that no matter how long a list of specified purposes was inserted in the act as objects for which cities and towns could borrow, there would necessarily arise from time to time cases in numerous municipalities where they would want to borrow money for some specific purpose which every one might agree was perfectly legitimate in that particular case, and yet which it would be extremely dangerous to incorporate in a general law, because it would be taken undue advantage of. I think you gentlemen can all appreciate the point of that argument. How to provide for these cases was considerable of a problem. And in making my recommendations and in the first draft of the bill, a state board to pass upon that subject was provided for; but the committee to which this report was referred looked askance on that proposition and felt it would be taking away from the legislature

certain of its traditional functions, and that it would be very difficult indeed to get such a proposition through the legislature. In fact, I think the committee itself was very strongly opposed to it, and it was, therefore, decided to pass this general act and leave it to the municipalities that could not borrow in cases of emergency under the general act to take them before the legislature and ask for special legislation.

As I have said, we had these two investigations: First, a preliminary and rather superficial investigation, — that is, while it was thorough enough as far as it went, it didn't take in all aspects of the subject and was necessarily made in a short space of time; and then a more comprehensive investigation, which I think was generally regarded as a very thorough going over of the subject. We took our time for it, we spent nearly a year on it, and made our report to the legislature. In the meantime I was asked to make a special report on the subject of sinking funds and serial bonds, which resulted in the incorporation of the prohibitory clause as regards sinking funds to which I have referred. So that the Bureau of Statistics made three investigations of this subject.

The report came in in the latter part of the session of 1912, too late for considerate action by the legislature that year, and they thought the matter was of sufficient importance to justify the appointment of a special recess committee, and such a committee was appointed. Our report was entirely a statistical report, based upon an examination of the local accounts and statistics of debt, which we classified as well as could be done under the circumstances. The legislative committee approached the problem from an entirely different angle. They took this report as a basis of inquiry and then summoned before them the mayors of the thirty-three cities of the Commonwealth and the tax collectors and the assessors and the treasurers and the auditors of the cities, and the same officials of about seventy-eight towns, — they couldn't go over the whole list of three hundred and twenty towns, — and these towns were selected as to size and geographical location, and the committee, I believe, even traveled in the western part of the state, so that they got a pretty good line on the situation from the standpoint of the local officials, and their report was of peculiar value from that point of view. They made their

report to the Legislature of 1913, and that legislature appointed a special committee to which this special report and bill were referred, and the local officials throughout the state were again notified.

The committee did not satisfy itself with the usual somewhat perfunctory advertising of the hearings in the newspapers, but the officials throughout the state, the local officials, were notified and furnished with a draft of the bill and advised that if they had anything to say about it, the committee would be very glad to hear them. The point I am trying to make in this connection is that this legislation was the result of three distinct investigations by the Bureau of Statistics, scientifically made, and subjected to subsequent inquiry and going over of the subject by two legislative committees, — one of which sat almost continuously on the job, with hearings day after day for three or four months during the autumn of 1912, — and the regular standing committee of the legislature; so that this legislation really ran the gauntlet of, you might say, five investigations and inquiries; and I think I am entirely within the facts when I express the opinion that no piece of legislation ever put on the statute books of the Commonwealth was more thoroughly predigested, if I may use that term, than this general Municipal Indebtedness Law.

I think that Mr. Sherman, in the remark that he interpolated in his paper, in a measure hinted at a very important matter that should be taken into consideration, as to whether the liability to abuse in the letting down of the bars in this matter may not perchance be greater than the conceivable benefits in a few cases; and that is obviously something that we will all agree should be given very careful consideration, and which no doubt will be given careful consideration, by the legislative committee when this matter comes before them.

I think that is all I care to say by way of general statement. If Mr. Waddell has anything specific which he would like to offer, and you would like to hear him, I am very sure he would be glad to speak to you. Mr. Waddell, I may say, is the Chief of the Municipal Division of the Bureau of Statistics, which as a department, as you doubtless know, covers a wide range of statistical inquiry, and is organized into several divisions, and Mr. Waddell

is my assistant and adviser at the head of this particular branch of the work.

MR. T. N. WADDELL.* Mr. President, it is needless to say that I am very much interested in this particular legislation, since during the past three years the greater portion of my time has been devoted to working out problems of financing cities and towns. I would like to explain why the section mentioned in the paper, which permitted the borrowing for five years only for the extension of water mains, was enacted. It was for this reason: We were unable to convince the committee that the general law that permitted cities and towns to borrow for certain purposes should be extended and that municipalities should be permitted to borrow for water purposes under the ten per cent. limitation clause. The proposition was how to eliminate any borrowing whatever through general law other than for the establishment of new plants. It was shown that in many cities and towns new sections were being developed, and it was only fair that some borrowing be permitted for such development. It had been the practice, I am sorry to say, to make these borrowings for extensions for thirty years, notwithstanding the fact that they were annually recurring charges; and from the paper I take it that Mr. Sherman does not approve of borrowing for those purposes at all. Yet it seemed to us that permitting borrowing for five years, which would take care of the development of certain sections of a town, would permit of only slight abuse should you consider the town as borrowing for five years for annually recurring expenses.

The section as to districts was brought to our attention in a very forcible manner. As the certification of town and district notes goes through our office, it was our duty to determine whether or not (in our opinion) they were perfectly legal; and having before us certain district loans, the question was raised, On what authority are these to be issued? The fact is that there was no authority under general law for a district to borrow money, and I will not hazard a guess as to the amount of illegal loans outstanding to-day on account of districts. It is capable of demonstration that there are some, because we have drawn two bills to validate loans that we positively knew were outstanding. Last

* Chief of Municipal Division, State Bureau of Statistics.

year we undertook to draw a bill for refunding a certain indebtedness which had been outstanding for twenty-nine years, without a single solitary cent set aside for the payment of the debt. It seemed to us that with the ever-increasing indebtedness, some step must be taken to at least reduce, if not stop. The serial method will, in a way, control; as a matter of fact, it hasn't reduced indebtedness thus far. The indebtedness for water supply systems in the small towns of our Commonwealth — and I take it it is only the small towns that this Association is deeply interested in at this time, because the large towns and the cities all have going concerns — actually increased in 1911 over 1910, in 1912 over 1911, and in 1913 over 1912. For those reasons we feel as though the annual payment clause should be retained.

From certain papers which I have read I find that there is a way of financing these extensions. There is no doubt that the health question enters into your water supply systems, and it isn't the purpose of our office in any way to interfere or attempt to interfere with any legitimate health measure; but we do feel that you ought to bring the matter squarely before the people and let them understand that if a burden is to be placed on the town they should bear their portion of it, for posterity most certainly will have troubles of its own.

In financing any plant, admitting it will take somewhere near a year to construct the plant, the statute makes ample provision for financing with a temporary loan, and when the plant is constructed it can be financed then by a permanent loan, and that permanent loan will represent the actual amount that is necessary to construct the plant; whereas if the permanent loan is made in the first instance, you as business men know that you are likely to be over or under, and sometimes when you have funds on hand it is a question where you want to place them. You certainly don't want to put operating costs into thirty-year loans. By financing the first year with a temporary loan, replaced the second year with a permanent loan, you have two years in which to obtain money to meet your first charge on principal. You have to apply on that such sums as will be obtained from premiums, and I don't believe it is necessary to enter into any subterfuge to obtain money from premiums, because the market conditions are such that cer-

tain rates are almost demanded. In fact, to-day, even although you could get a loan on a 3.85 or a 3.79 basis, it would be insisted that the loan should be written on a 4 per cent. basis; so it seems to me that the burden is not so great as to warrant a change in the statute at this time.

I can assure you, gentlemen, from the little experience I have had with legislative committees, that if a new concern gets five years' exemption, every going concern will get five years' exemption. That is certain to follow. Not infrequently you hear it said: "So-and-so got five years, why can't I have it?" But if you have a rule, and constantly live up to it, there is less trouble and less grumbling; and I believe every one should share his portion of the expense. It seems to me that this is no more than we ought to insist upon, in view of the condition of the finances of our cities and towns to-day. The charge on account of interest is simply alarming, and an increase of indebtedness in the last four years of some $15 000 000 in our cities and towns brings before you, gentlemen, something that you want to take into consideration in conjunction with your water supply systems; because the water rates are a tax, the same taxpayer who pays the water rates is the taxpayer who pays the tax, and while the water system is usually looked upon as a self-supporting enterprise, the fact remains, if there is a health measure, and if that is the basis of your argument, why shouldn't you tax the property holder for this health measure, just as you tax him for other health measures?

The burden is not great, and in but few instances can it be shown that it will affect the tax rate more than a dollar on a thousand, and we can show you case after case where the poor town is willing to put $3 or $5 into its tax rate to build roads for the automobilists to ride on and the taxpayer has no use whatever for them himself. I don't believe the burden is great enough to justify a change from the seriously considered limitations, and the increasing ratio has proved that you are going to get almost as unwarrantable a situation as we had under the old statute. It might be equalized, but with the officials with whom we come in contact, — and they are as honest as the day is long, — it would be utterly impossible without expense for legal advice for them legally to issue indebtedness along those lines.

Nothing should be done to prevent a city or town or a district from supplying itself with water, but everything should be done to encourage each district to bear its portion of the burden. If the town is too large to be supplied, organize your district. And it was for that very reason that we were anxious to secure some legislation whereby districts could borrow for exactly the same purposes permitted to cities and towns, as we knew of no statute and no general law under which they could borrow for more than temporary purposes, namely, a one-year loan.

MR. HIRAM A. MILLER.* Mr. President, I was very much interested in the bill of 1913, and am now. I think it was a good bill, as towns and cities are too apt to postpone and to leave posterity to pay bills which they should pay themselves. While the amendments which are proposed do not, I think, in general materially affect the general principle of the bill of 1913, I think that the one which postpones the first payment for five years and then requires payment of only one half as much in any year as may be paid in any subsequent year defeats the very object of the bill of 1913. On a thirty-year loan this would permit a municipality to let the loan run for five years without any payment of principal, and then for the next twelve years to pay only one half as much as for the last thirteen years, the result being that the municipality would postpone until the last one third of the time for which the bonds run the payment of over one half of the bonds, and probably at that time the municipality would want an additional extension of the water works and they would not only have to finance that, but to pay off in ten years over one half of the loan which had been made twenty to thirty years previous. For that reason I think that amendment to the existing law is altogether too radical and should not be adopted.

On the question of postponing payments of principal for five years; on account of the small revenue that would be received the first two or three years, and on account of the fact that there would be a good deal of interest to be paid during the construction and before the works were of any great value to the community, — I think the postponement of it for five years, and also the postponement of special improvements in the way of large mains, etc., for

* Consulting Engineer, Boston, Mass.

five years, would be proper enough and wouldn't materially change the general principle of the bill of 1913; but the amendment to prevent a municipality to pay less in any year than in any subsequent year I am very strongly opposed to.

MR. SHERMAN (*by letter*, April 18, 1916). Petition for the legislation suggested in the foregoing paper was duly presented to the legislature and was referred to the Committee on Municipal Finance, which gave a hearing in regular form, at which a number of persons argued in favor of the bill and none in opposition. After considerable further deliberation the committee reported in favor of a portion of the legislation asked for, and the legislature adopted their recommendation in the following Act:

[GENERAL ACTS.]

[CHAP. 62.]

AN ACT RELATIVE TO THE PAYMENT BY CITIES AND TOWNS OF BONDS ISSUED FOR WATER SUPPLY PURPOSES.

Be it enacted, etc., as follows:

SECTION 1. Section fourteen of chapter seven hundred and nineteen of the acts of the year nineteen hundred and thirteen is hereby amended by adding at the end thereof the following: — *provided, however,* that in the case of bonds or notes issued in accordance with clause (2) of section six of this act the first of such annual payments shall be made not later than three years after the date of the bonds or notes issued therefor, — so as to read as follows: — *Section 14.* Cities and towns shall not issue any notes payable on demand, and they shall provide for the payment of all debts, except those incurred under the provisions of sections three, four and nine, by such annual payments as will extinguish the same at maturity, and so that the first of such annual payments on account of any loan shall be made not later than one year after the date of the bonds or notes issued therefor, and so that the amount of such annual payments in any year on account of such debts, so far as issued, shall not be less than the amount of principal payable in any subsequent year, and such annual amount, together with the interest on all debts, shall, without further vote, be assessed until the debt is extinguished: *provided, however,* that in the case of bonds or notes issued in accordance with clause (2) of section six of this act the first of such annual payments shall be made not later than three years after the date of the bonds or notes issued therefore.

SECTION 2. Section five of chapter eighty-five of the General Acts of the year nineteen hundred and fifteen is hereby amended by adding at the end thereof the following: — *provided, however,* that the first of such annual

payments on account of a loan incurred for the original construction or purchase of a water works system shall be made not later than three years after the date of the bonds or notes issued therefor, — so as to read as follows: — *Section 5.* Districts shall not issue any notes payable on demand, and they shall provide for the payment of all debts, except those incurred under the provisions of sections three and nine of chapter seven hundred and nineteen of the acts of the year nineteen hundred and thirteen, as amended, by such annual payments as will extinguish the same at maturity, and in such manner that the first of such annual payments on account of any loan shall be made not later than one year after the date of the bonds or notes issued therefor, and that the amount of the annual payment in any year on account of any such debt, so far as it may be issued, shall not be less than the amount of principal payable in any subsequent year: and such annual amounts, together with the interest on all debts, shall, without further vote, be assessed until the debt is extinguished: *provided, however,* that the first of such annual payments on account of a loan incurred for the original construction or purchase of a water works system shall be made not later than three years after the date of the bonds or notes issued therefor.

SECTION 3. This act shall take effect upon its passage. [*Approved March 21, 1916.*]

MUNICIPAL WATER-WORKS FINANCING IN MASSACHUSETTS AS AFFECTED BY RECENT LEGISLATION.

BY CHARLES W. SHERMAN, WILLIAM S. JOHNSON, AND HENRY A. SYMONDS.

It is generally accepted as a self-evident truth that a revenue-producing public-service enterprise, whether or not owned by the municipality, should be self-supporting. The writers feel very strongly that this view is the only correct one, and that anything which renders it difficult or impossible for a water-works system to maintain itself financially is only a trifle less objectionable than taking away the revenue of a water-works system for maintaining streets or other general public uses. Under present laws, however, it is impossible in Massachusetts for a newly established water works to meet its obligations, and it must be supported in considerable measure out of general taxation, thus bringing a heavy burden upon taxpayers who may not be directly benefited by the introduction of water. It is the purpose of the writers to show how present laws affect these conditions and to suggest a remedy.

In former years, the possibility of so arranging the loans for water-works construction that payment of principal might be deferred until the works should have had opportunity to develop a revenue has been in many cases a potent factor in securing the establishment of water-works systems; but the present laws have changed all this and it is no longer possible to make such arrangements of bonds except by virtue of special legislation, which it is very difficult to obtain when opposed to existing general laws.

Until 1913, water-works construction in municipally owned plants in Massachusetts could be financed by bonds running for a period not exceeding thirty years (except as otherwise stipulated in special legislation), due provision being made for retiring such bonds by sinking funds or by serial payments. This was in ac-

cordance with general laws (Revised Laws of Massachusetts, 1902, Chap. 27, Sects. 11, 12, and 13), and there was no distinction between original construction and extensions of works.

Until 1910 there was no provision of law governing the disposal of premiums obtained from the sale of such bonds. At least in some cases, such premiums have been diverted to other municipal purposes, perhaps for maintenance work not in any way related to the purposes for which the bonds were issued. In 1910, on the petition of one of the writers, the legislature passed Chapter 379 of the Acts of that year, providing that in case of sinking fund bonds any premium received should be added to the sinking fund, and the annual contribution correspondingly reduced, and that in the case of serial bonds the premium should be used in retiring the bonds first to mature.

In 1913 the legislature passed an Act, Chapter 719, radically changing the conditions affecting water-works finances. This act provided, in Section 6, that cities and towns may incur debts outside the debt limit, for a period not exceeding thirty years, for the establishment or purchase of a system of water-works, or for the purchase of land for the protection of a water system, or for acquiring water rights; but for the extension of water mains and for water departmental equipment the term of such loans was limited to five years. It was further provided that the proceeds of the sale of any such bonds, with the exception of premiums, should be used only for the purposes specified in the authorization of the loan, except that transfers of unexpended amounts might be made to other accounts to be used for similar purposes. The disposition of premiums, as stipulated by the Act of 1910, remained unchanged. Section 8 provided, among other things, that bonds might be issued " at such rates of interest as may be deemed proper," and that they should be sold at not less than par. Section 13 provided that no further sinking fund bonds should be issued, and Section 14 required that all new bonds be retired by annual payment, the first payment to be made not later than one year after the date of the bonds, and the payment of principal in any year not to be less than the amount payable in any subsequent year.

It will be seen that this act radically changed the conditions

under which money might be borrowed for water-works extensions. While loans for the construction of new works or the purchase of old ones, for acquiring water rights or land for the protection of the water supply, may run for thirty years, all other extensions of water works must be financed on a five-year basis. It will also be noted that in retiring serial bonds, the first payment must be made within one year of the date of the bond, and the payments in the earlier years must be at least as large as, and in many cases larger than, in later years.

These conditions are all of such a nature as to cause hardship in a great many cases, or else, in a large measure, to neutralize the attempts which have been made by people interested in water-works financing to so arrange matters that water works shall be wholly self-supporting.

It is obvious that if water-works constructions are of such a length of life that thirty-year bonds are reasonable in the case of new works or in the purchase of existing works, they would be equally reasonable in the case of extensions. It is well known that very little in the nature of water-works construction has a useful life of less than thirty years, and much of the work has a very much greater life. Thus there is no practical possibility of future generations being called on to pay debt requirements for works which have then disappeared, even in the case of thirty-year loans. Doubtless it is not good financing to borrow money year after year for comparatively small expenses, which are annually recurring, such, for instance, as may be demanded by the annual requirement of installing meters, service-pipe connections, and for ordinary extensions of main pipe to reach new houses, under average conditions. The best financial policy is unquestionably to take care of such requirements out of revenue. On the other hand, special requirements of certain years, such as an unusual reinforcement of the main pipe system, the installation of a new supply, the construction of a new pumping unit or reservoir, may well call for an expenditure in addition to the ordinary annual expenditure for extensions, which it is impracticable to meet out of the revenue of a single year, or, indeed, out of the revenue of five years, without so loading the revenue as to make impossible the payment of fixed charges which, under the provisions of law, would

make necessary the assessment of interest and debt requirements out of taxation.

This condition may be illustrated by the case of the Town of Belmont, where it has been customary for many years to take care of ordinary extensions, as well as interest, sinking-fund and serial-bond requirements, out of water-department revenue. Prior to 1910 the ordinary requirements for construction of mains were about $2 500 annually, and from 1911 to 1914, inclusive, they have ranged from $4 500 to $9 000 annually. In 1913, owing to the very rapid growth of the town, the water works was faced with the necessity of laying a considerable amount of large-sized pipe to reinforce the distribution system. The estimated cost of this improvement was $17 000, in addition to the ordinary requirements for extensions of mains to new houses. It would obviously have been impossible to meet any such sum out of the current revenue. Even under a five-year loan, as required by the present law, the annual requirement for maturing bonds and interest would have ranged from $4 265* in the first year to $3 135* in the fifth year, or nearly as much as the entire sum required for ordinary annual extensions. To meet any such requirement would have necessitated curtailing other necessary expenses or funding them in the form of five-year loans. As a matter of fact, — the law above-referred to not having been enacted at the time this matter came up for discussion, — the bonds were issued for a thirty-year term, with the result that the annual interest and serial-bond requirement was $1 765 the first year and $1 630 the fourth year ($1 000 of bonds maturing annually during this period), and ranged from $1 085 in the fifth year to $522.50 in the thirtieth year, during which period $500 of bonds matured annually. These sums, added to the regular requirements, do not materially increase the burden upon the works.

The folly of borrowing for annually recurring expenditures for ordinary extensions under the five-year loan proposition may be illustrated by the following case: Assumed annual requirement for extension, $8 000, funded in five-year bonds, maturing $1 600 each year; rate of interest, 4 per cent. During the first four years the annual requirement for maturing bonds and interest would in-

* Interest rate, $4\frac{1}{2}$%.

crease from $1 920 to $7 296, and thereafter would remain uniform at $8 960; in other words, after the fifth year there would be spent each year $8 960 to do $8 000 of work, and there would be $24 000 of bonds constantly outstanding. The case is even worse for bonds issued for longer periods; that is to say, borrowing for annually recurring expenses results in material losses.

The only escape from such hardship as would exist in the case of Belmont, quoted above, would seem to be to obtain a special act of the legislature authorizing a longer term for the particular loan under consideration, and such special acts are difficult to obtain.

The provision of law which requires that serial bonds shall be retired by payments, the first of which shall be made not later than one year from the date of the bonds, and which shall not be less than in any succeeding year, is also a hardship, particularly in the case of new works. Assume, for instance, the case of a small town constructing a water-works system costing $60 000. For the construction of the new works its bonds may run for a period of thirty years, but it must begin to pay serial bonds not later than one year from the date of issue, — that is, by the end of one year it must pay at least $2 000 in bonds in addition to the interest on the whole $60 000 for the year. In all probability, nearly a year from the date of borrowing the money will elapse before the works can be completed and put in operation, and the sum to be received in earnings during this time is insignificant. It is, therefore, impossible that the earnings of the water department shall have provided a sum sufficient to pay interest and serial bonds in addition to such operating expenses as may have been incurred during that period. Therefore, under the provisions of law, it will be necessary for the assessors to assess the interest and bond requirements as a part of the tax. During the early years, when none, or at most but a small part, of the bonds have been retired, the interest payments are at their maximum, so that the total demands for interest and maturing bonds are most severe at the time when the works have not developed a revenue and are in the worst condition to meet them. Imagine a private company trying to conduct business on this basis! How long would it continue to exist?

A possible mode of evading this condition exists under the present requirement with regard to premiums. It will be noted that the bonds may be issued at such rates of interest as may be reasonable. At the present time there is a good market for municipal bonds in Massachusetts at 4 per cent., and a slight premium can be obtained. Assuming new works to be started at this time, it might be decided to issue the bonds at 4¼ per cent. or 4½ per cent., and such bonds would command a handsome premium, sufficient to take care of the first bonds to mature, — possibly for those maturing within the first two or three years, during which period the works may get upon such a basis that the revenue can care for the debt requirements.

The difficulties of meeting this situation are increased by the provision that the payment of principal shall in no year be less than that of any subsequent year. For instance, assuming a small town building water works to cost $40 000, and issuing bonds for thirty years. If the common practice of issuing bonds in $1 000 pieces is followed, it will be necessary to retire not less than $2 000 of bonds each year during the first ten years; while during the succeeding twenty years the amount to be retired will be but $1 000 every year. The interest requirement (at 4 per cent.) would be $1 600 the first year and but $40 in the thirtieth year, making total charges of $3 600 in the first year, as against $1 040 in the thirtieth year. Thus the load on the water revenue is greatest at the time when the revenue is smallest and least able to meet heavy expenses. The water earnings will certainly be unable to stand the strain, and it will be necessary to call upon general taxation to carry the work during the earlier years. In such a case it is likely that the water rates would be reduced after ten or twenty years, as the fixed charges would then be so small, and the taxpayers would thus be paying during the early years of the works for water used by water consumers in later years; while many of these taxpayers, living in outlying sections, would be benefited only indirectly by the water-works system.

Such conditions as are outlined above obviously discourage the installation of new water works. The taxpayers, at least if the conditions are carefully analyzed in advance, will feel that they are not only asked to lend their credit for water-works bonds,

but that for a number of years during the early history of the works they must advance material sums out of the tax revenue to keep the works going. Under such conditions the construction of water works will be postponed as long as possible.

It will be noted that the Act of 1913 applies only to cities and towns. It was therefore still possible for water districts to issue bonds upon a different basis without contravening existing law, and this was done in a number of cases between 1913 and 1915. It was usually provided in issuing such loans that the first payment of principal should be made five years after the date of the bonds.

Unfortunately, however, a bill was introduced to the legislature of 1915, which extended the restriction to water districts, and as the title of the bill was somewhat blind and as it was referred to the Committee on Municipal Finance and not to the Committee on Water Supply, water-works men in general did not discover that such a proposition was under consideration until it was too late to take any action, and Chapter 85 of the Acts of 1915 had been passed. This chapter, by Section 5, practically extends the provision of the Act of 1913, above referred to, so that in the case of water districts, as in the case of cities and towns, the first payment of serial loans must be made not later than one year from the date of the issue of the bond.

It is believed that the bills to which we have herein taken objection were introduced into the legislature, and enacted by it, with the best of intentions, but without realizing what their effect must necessarily be. We believe, however, that the examples cited above, and numberless others which might be quoted, show that, whatever benefits may have resulted from these acts, — and it is not clear to us that there have been any benefits, — they have been obtained at the expense of other more desirable conditions. The undesirability of special legislation, except in cases of real necessity, is generally recognized. Yet the existing laws practically force every water-works system to apply for special legislation in the case of any unusual expenditure. The advantage of a municipal public-service enterprise being self-supporting is also admitted, but the present laws make it difficult, and in some cases impossible, for this result to be attained. The desirability

of the introduction of a public supply of water in municipalities of any considerable size is unquestionable, and most of us believe that, where there is sufficient public spirit in a community, it is wiser that such works be built by the municipality rather than by a private company. The existing laws, however, throw such difficulties in the way of successfully starting such an enterprise as to practically prohibit further construction in this way by the public. The effect must necessarily be the original construction of such works by private companies. If municipal ownership is desired, it will be necessary that the municipality wait until the private enterprise is on a paying basis, when it may be expected that the income from the established business will be sufficient to carry the necessary investment.

The writers of this paper have petitioned the present legislature for an amendment to the existing laws, which will, it is believed, correct the conditions outlined in this paper. The present laws, and their form if amended as suggested, are as follows:

EXISTING LAWS.	CHANGES SUGGESTED BY PROPOSED AMENDMENTS.
Chapter 719, Acts of 1913.	
SECT. 6. Cities and towns may incur debt, outside the limit of indebtedness prescribed in this act, for the following purposes and payable within the periods hereinafter specified:	
(1) For temporary loans under the provisions of sections three, four or nine, one year.	(Unchanged.)
(2) For establishing or purchasing a system for supplying the inhabitants of a city or town with water, or for the purchase of land for the protection of a water system, or for acquiring water rights, thirty years.	(Unchanged.)
(3) For the extension of water mains and for water departmental equipment, five years.	(3) For the extension of water mains and for the construction of reservoirs, standpipes, pumping stations, and pumping equipment, twenty years.

EXISTING LAWS.

CHANGES SUGGESTED BY PROPOSED AMENDMENTS.

(4) For the purchase and installation of water meters and for other water departmental equipment not included in Clause 3, ten years.

(4)* For establishing, purchasing, extending or enlarging a gas or electric lighting plant within the limits of the territory within which such gas or electric lighting plant is authorized to distribute its product, twenty years; but the indebtedness so incurred shall be limited to an amount not exceeding in a town five per cent. and in a city two and one-half per cent. of the last preceding assessed valuation of such town or city.

(Clause 5 will be old Clause 4 unchanged but renumbered.)

SECT. 14. Cities and towns shall not issue any notes payable on demand, and they shall provide for the payment of all debts, except those incurred under the provisions of sections three, four and nine, by such annual payments as will extinguish the same at maturity, and so that the first of such annual payments on account of any loan shall be made not later than one year after the date of the bonds or notes issued therefor, and so that the amount of such annual payments in any year on account of such debts so far as issued shall not be less than the amount of principal payable in any subsequent year, and such annual amount, together with the interest on all debts, shall, without further vote, be assessed until the debt is extinguished.

(Unchanged.)

Add, — provided, however, that in the case of bonds issued in accordance with Clause 2 of Section 6 of this Act, the first of such annual

* As amended by Chapter 115, Acts of 1915

EXISTING LAWS.	CHANGES SUGGESTED BY PROPOSED AMENDMENTS.
	payments shall be made not later than five years after the date of the bonds or notes issued therefor, and the amount of annual payment in any year on account of such bonds shall not be less than one half the amount of principal payable in any subsequent year.
Chapter 85, Acts of 1915. SECT. 5. Districts shall not issue any notes payable on demand, and they shall provide for the payment of all debts, except those incurred under the provisions of sections 3 and 9 of chapter seven hundred and nineteen of the acts of the year nineteen hundred and thirteen, as amended, by such annual payments as will extinguish the same at maturity, and in such manner that the first of such annual payments on account of any loan shall be made not later than one year after the date of the bonds or notes issued therefor, and that the amount of the annual payment in any year on account of any such debt, so far as it may be issued, shall not be less than the amount of principal payable in any subsequent year; and such annual amounts, together with the interest on all debts, shall, without further vote, be assessed until the debt is extinguished.	(Unchanged.)
	Add, — provided, however, that the first of such annual payments on account of a loan incurred for the original construction or purchase of a water-works system shall be made not later than five years after the date of the bonds or notes issued therefor, and that the amount of the annual payment in any year, on account of any such debts for the original construction or purchase of such water-works system, so far as it may be issued, shall not be less than one half the amount of the principal payable in any subsequent year.

PROCEEDINGS.

HOTEL BRUNSWICK,
BOSTON, MASS., March 8, 1916.

William F. Sullivan, President, in the chair.
The following-named members and guests were present:

HONORARY MEMBERS.

E. C. Brooks, R. C. P. Coggeshall, Albert S. Glover, Frank E. Hall. — 4.

MEMBERS.

S. A. Agnew, C. L. Baker, L. M. Bancroft, F. A. Barbour, A. E. Blackmer, J. W. Blackmer, C. A. Bogardus, G. A. Carpenter, J. C. Chase, H. S. Clark, H. W. Clark, John Cullen, J. M. Diven, E. D. Eldredge, G. F. Evans, F. F. Forbes, Patrick Gear, H. T. Gidley, F. J. Gifford, H. J. Goodale, J. W. Graham, R. K. Hale, A. R. Hathaway, D. A. Heffernan, W. F. Howland, J. L. Howard, A. C. Howes, J. A. Hoy, E. F. Hughes, G. A. Johnson, W. S. Johnson, E. W. Kent, Willard Kent, Patrick Kiernan, G. A. King, Horace Kingman, Morris Knowles, E. J. Looney, P. J. Looney, F. A. McInnes, S. H. McKenzie, Thomas McKenzie, W. A. McKenzie, Hugh McLean, H. V. Macksey, A. E. Martin, W. E. Maybury, John Mayo, H. A. Miller, J. W. O'Neill, F. L. Northrop, H. N. Parker, Dwight Porter, T. A. Pierce, H. E. Perry, H. G. Pillsbury, G. A. Sampson, C. M. Saville, A. L. Sawyer, C. W. Sherman, H. H. Sinclair, Sidney Smith, G. H. Snell, G. A. Stacy, W. F. Sullivan, E. J. Titcomb, D. N. Tower, C. H. Tuttle, W. H. Vaughn, Ernest Wadsworth, R. S. Weston, W. J. Wetherbee, L. J. Wilber, F. B. Wilkins, F. I. Winslow, G. E. Winslow, I. S. Wood. — 77.

ASSOCIATES.

Builders Iron Foundry, A. B. Coulters; A. M. Byers Co., H. F. Fiske; Central Foundry Co., W. Todd and W. H. Feltt; Chapman Valve Mfg. Co., C. E. Pratt and J. T. Mulgrew; Darling Pump and Mfg. Co., H. A. Snyder; Eddy Valve Co., H. W. Dotten; F. H. Hayes Machinery Co., F. H. Hayes; Hersey Mfg. Co., Albert S. Glover, J. H. Smith, and W. A. Hersey; Lead-Lined Iron Pipe Co., T. E. Dwyer; Ludlow Valve Mfg. Co., G. A. Miller; H. Mueller Mfg. Co., G. A. Caldwell; National Meter Co., H. J. C. Lufkin; National Water Main Cleaning Co., B. B. Hodgman; Neptune Meter Co., H. H. Kinsey and R. D. Wertz; Pittsburgh Meter Co., J. W. Turner; Rensselaer Valve Co., C. L. Brown; Ross Valve Mfg. Co., William Ross; A. P. Smith Mfg. Co., F. L. Northrop; Thompson Meter Co., E. M. Shedd; Union

Water Meter Co., F. E. Hall and Edward Otis; Water Works Equipment Co., W. H. Van Winkle; R. D. Wood & Co., H. M. Simons; Henry R. Worthington, Samuel Harrison and W. F. Bird. — 30.

GUESTS.

Richard Comerford and P. M. Thea, Worcester, Mass.; Neil Collins, Cambridge, Mass.; James Kinlock, East Greenwich, R. I.; W. B. Gerrish, Springfield, Mass.; Geo. E. Hildreth, Manchester, Mass.; Robert Beverage, Attleboro, Mass.; Leroy Peterson, Duxbury, Mass. — 8.

The Secretary presented applications for membership, duly recommended and endorsed, from J. W. O'Neill, Montreal, Canada, engaged with the water works, Montreal, for the past nineteen years, now chief of meter and inspection departments; Samuel Dyer, Attleboro, Mass., city engineer; Samuel M. Gray, Providence, R. I., engaged in the designing, construction, and maintenance of water works and sewers, and railroad work, in various parts of the country, for many years; W. B. Everett, Montesano, Wash., manager Northwest Electric & Water Works, Montesano, Wash.; George W. Simons, Jr., 1075 Boylston St., Boston, Mass., assistant, civil engineering department, Massachusetts Institute of Technology; E. L. Strauss, Cleveland, Ohio, president of the Central Brass Manufacturing Company (for associate membership).

On motion, the Secretary was directed to cast one ballot in favor of the admission of the applicants, and he having done so they were declared duly elected members of the Association.

The President called on Mr. Charles W. Sherman to give a brief résumé of the report of Committee on Meter Rates. Mr. Richard K. Hale read a discussion which Mr. Allen Hazen sent him from San Francisco, also a letter from Mr. A. E. Walden, of the Baltimore County Water and Electric Company. The President called on Mr. Caleb M. Saville, who read a discussion and made the following motion: That the final action on the report of the Committee on Meter Rates be postponed until the first fall meeting, and that the committee be requested to submit other methods of rate schedule that were considered by them.

The discussion on the report and also on Mr. Saville's motion was participated in by Messrs. McLean, Macksey, Coggeshall,

Diven, Brooks, McKenzie, Gear, William S. Johnson, Barbour, and Gill. The President then put the motion, and declared it unanimously adopted and the matter recommitted to the committee.

Mr. Robert Spurr Weston, Boston, read a paper on "The Proposed Auxiliary Water Supply for the City of Brockton." The paper was discussed by Mr. George A. Johnson.

The last business on the program for the afternoon was entitled "Preliminary Report of Committee on Service Pipe." The President called on Mr. William S. Johnson, the chairman of the committee, who summarized the report. The President, Mr. A. E. Martin, and Mr. Coggeshall made brief remarks; and on the President's suggestion that the matter be postponed until the annual meeting, thereby hoping to get a broader discussion, Mr. Horatio N. Parker made a motion to that effect. The motion was seconded and unanimously adopted.

JUNE MEETING.

PEMBERTON INN,
PEMBERTON, MASS., June 21, 1916.

The June meeting of the New England Water Works Association was held at Pemberton Inn., Pemberton, Mass., June 21, 1916, in conjunction with the Boston Society of Civil Engineers.

The following members and guests were present:

HONORARY MEMBERS.

Edwin C. Brooks, R. C. P. Coggeshall, Albert S. Glover, Frank E. Hall, George A. Stacy. — 5.

MEMBERS.

D. L. Agnew, S. A. Agnew, C. L. Baker, L. M. Bancroft, F. A. Barbour, J. F. Barrett, C. H. Bartlett, J. W. Blackmer, E. M. Blake, G. A. Carpenter, P. M. Churchill, S. K. Clapp, F. L. Cole, C. W. Ellis, Jr., C. H. Eglee, Frank Emerson, James Fitzgerald, F. L. Fuller, H. F. Frost, Patrick Gear, F. J. Gifford, J. A. Gould, R. A. Hale, J. O. Hall, D. A. Heffernan, C. R. Hildred, J. L. Howard, E. F. Hughes, C. E. Johnson, W. H. Jaques, W. S. Johnson, Willard Kent, G. A. King, C. F. Knowlton, Godfrey Knight, W. F. Learned, F. A. McInnes, J. N. McKernan, Hugh McLean, A. D. Marble, A. E. Martin,

W. E. Maybury, John Mayo, F. E. Merrill, G. F. Merrill, J. H. Perkins, H. G. Pillsbury, W. H. Pitman, J. H. Remick, A. L. Sawyer, G. G. Shedd, J. E. Sheldon, Sidney Smith, G. H. Snell, J. T. Stevens, W. M. Stone, W. F. Sullivan, H. A. Symonds, S. E. Tinkham, D. N. Tower, L. R. Washburn, W. J. Wetherbee, F. H. White, F. B. Wilkins, G. E. Winslow, D. M. Wood, I. S. Wood. — 67.

ASSOCIATES.

Harold L. Bond Co., by F. M. Bates and H. L. Bond; Builders Iron Foundry, A. B. Coulters; Central Brass Mfg. Co., M. J. Herschfield; Chapman Valve Mfg. Co., J. F. Sullivan, V. N. Beagle, C. E. Pratt, J. T. Mulgrew, and H. U. Storrs; Darling Pump & Mfg. Co., H. A. Snyder; Eddy Valve Co., H. A. Holmes, H. W. Dotten; Hersey Mfg. Co., J. H. Smith, Albert S. Glover, W. A. Hersey; Kennedy Valve Co., M. J. Brosnan; Ludlow Valve Mfg. Co., G. A. Miller; H. Mueller Mfg. Co., G. A. Caldwell; National Meter Co., J. G. Lufkin; National Tube Co., J. E. Fleming; Neptune Meter Co., R. D. Wertz; Norwood Engineering Co., F. M. Sears; Pittsburgh Meter Co., J. W. Turner; Rensselaer Valve Co., F. S. Bates, C. L. Brown; Ross Valve Mfg. Co., William Ross; A. P. Smith Mfg. Co., F. L. Northrop; Standard Cast Iron Pipe & Foundry Co., W. F. Woodburn; Thomson Meter Co., E. M. Shedd; R. D. Wood & Co., H. M. Simons; Henry R. Worthington, W. F. Bird, E. P. Howard, and Samuel Harrison. — 33.

GUESTS.

Maine: South Harpswell, Rear Admiral (retired) R. E. Peary. New Hampshire: Little Boar's Head, Mrs. W. H. Jaques. Massachusetts: Allston, E. G. Kinsey; Andover, Mrs. F. L. Cole; Arlington, Mrs. E. M. Shedd; Belmont, Mrs. Dana M. Wood, Master J. Elliott Wood; Beverly, Mr. and Mrs. Thomas A. Appleton, Arthur B. Appleton, H. G. Porter; Brookline, Mrs. C. H. Eglee; Boston, Mrs. Frank M. Bates, Herbert W. Dyer, Miss Mary E. Evans, Mr. A. Friend, Charles F. Glavin, Miss M. E. Hallinan, Miss Joan M. Ham, C. E. Kelley, Mrs. A. M. Lovis, Mrs. J. Herman Smith, Master Ellsworth Smith, Mrs. S. E. Tinkham, F. P. Wilcox; Braintree, William C. Harrison, John Kelley, Mrs. W. E. Maybury, Louis W. Thayer; Bridgewater, Miss Beulah Hopkins, Mrs. John Mayo; Cambridge, Eugene F. Sullivan; Dedham, Mrs. Frank J. Gifford; Everett, Arthur L. Gammage; Florence, Mrs. F. M. Sears; Holyoke, Helen A. Hanley, Mrs. Hugh McLean, Marion McLean, Katharine G. Sullivan; Leominster, Mrs. W. J. Wetherbee; Malden, Mrs. Harold L. Bond, Mrs. William F. Woodburn; Melrose, Mrs. E. C. Brooks, Mrs. C. F. Knowlton, C. F. Knowlton, Jr., Mrs. A. M. Lovis; Mattapoisett, Manuel R. Kousahe; New Bedford, William A. Tucker; Newton, Alfred E. Burton, Thomas C. Davis, Ernest L. Foley; Norwood, Lyman W. Bigelow; North Andover, Frank E. Smith; Peabody, Edward A. Blaney, Joseph A. Ryan; Reading, Mrs. L. M. Bancroft; Randolph, Mr. and Mrs. John F. Thomas; Roxbury, George C. Ambrose; Shrewsbury, Romeo E. Allen; Somerville, Mrs. C. H. Bartlett, Helen G. Blake, Mrs. Samuel Harrison, Mrs.

C. R. Hildred; Waban, Mrs. H. A. Symonds; Waltham, A. W. Parker, Frank L. Preble, Mrs. G. E. Winslow; Watertown, John M. Cashman, Miss Mabel A. Perkins; Wellesley Hills, Mrs. F. L. Fuller, Miss Pearl M. Jones, Harriet C. Sammons; West Roxbury, Mr. and Mrs. C. H. Dodd, D. S. Reynolds. Rhode Island: Pawtucket, Mrs. G. A. Carpenter, Miss E. R. Whitaker; Providence, Horace T. Almy, M. A. Shaw, Mrs. I. S. Wood; Narragansett Pier, Mrs. Willard Kent. New York: Troy, Mrs. F. S. Bates. — 83.

The joint Field Day of the two organizations proved very enjoyable, and the program of ball game, dinner at Pemberton Inn, with musical and literary exercises, business meetings of Association and Society, was fully carried out, with an attendance of 193. Rear-Admiral Peary, U. S. N., Retired, was present as a guest, and favored the assemblage with a forceful and interesting address on the current topic of the hour, Preparedness.

At the business meeting of the New England Water Works Association, President William F. Sullivan presiding, seventy applications for active and one for associate membership were presented, viz., —

Frederic L. Andrews, Sanford, Me., superintendent; Frederick W. Bateman, Clinton, Mass., civil engineer; G. A. Bean, Derry, N. H., superintendent; George W. Bowers, Cleveland, Ohio, civil engineer; George F. Bourne, Lenox, Mass., water commissioner; Homer E. Bridge, Hazardville, Conn., manager and superintendent; James L. Bryne, Boston, Mass., construction engineer; John Byrne, Westbrook, Me., superintendent; B. R. Chapman, Brockton, Mass., city engineer; Guy H. Chase, Fitchburg, Mass., commissioner of streets and engineering; Joseph S. Craigue, Walpole, Mass., civil engineer; Charles W. Eddy, Thomaston, Conn., civil engineer; Charles W. Ellis, Jr., Mattapoisett, Mass., superintendent; Frank Emerson, Peabody, Mass., superintendent; Henry F. Frost, South Easton, Mass., treasurer; H. L. Foster, Boston, Mass., civil engineer; W. A. Gardner, Suffield, Conn., superintendent; Marshall R. Goding, Portland, Me., auditor; Pearl T. Gray, Portland, Me., registrar; J. Francis Granger, Marlboro, Mass., engineer; Jacob A. Handy, South Dartmouth, Mass., chairman water commissioners; George B. Hamblin, Whitinsville, Mass., purchasing agent; John V. Hazen, Hanover, N. H., instructor of engineering, Dartmouth College; Charles R. Hildred, Somerville, Mass., chief clerk, office of water department; Charles I. Hosmer, Turners Falls, Mass., hydraulic engineer; William L. Howard, Hingham, Mass.; William H. Jaques, Little Boar's Head, N. H., president Hampton Water

Works Company; Minol S. Kaharl, West Somerville, Mass., clerk, Wiscasset Water Company; J. Frank Kidder, Burlington, Vt., superintendent; Godfrey Knight, Avon, Mass., superintendent; Beardsley Lawrence, Dorchester, Mass., civil engineer; Joseph F. A. Leonard, Fall River, Mass., civil engineer; Sheldon E. Minor, Greenwich, Conn., civil engineer; Morton L. Miller, Springfield, Mass., master mechanic, water works; Oren M. Moulton, Gorham, Me., consulting engineer; Hugh Nawn, Roxbury, Mass., civil engineer; Reeves J. Newsom, Lynn, Mass., superintendent; John E. Palmer, Boston, Mass., consulting engineer; John Parsons, Somersworth, N. H., superintendent; Stanley G. Proverbs, New Bedford, Mass., hydraulic engineer; Edwin L. Pride, Boston, Mass., accountant; Joseph B. Sando, Boston, Mass., mechanical engineer; Harry W. Sawyer, Manchester, N. H., civil engineer; Walter H. Sawyer, Lewiston, Me., hydraulic engineer; Warren J. Simonds, Marlboro, Mass., city engineer; George G. Shedd, Manchester, N. H., consulting engineer; A. H. Starkweather, Wakefield, Mass., superintendent; Ralph Sweetland, Boston, Mass., engineer, Insurance Exchange; Frederic H. Taber, New Bedford, Mass., member water board; Alfred H. Terry, Bridgeport, Conn., city engineer; Alberti T. Thompson, Rockville, Conn., superintendent; Frank M. Travis, Torrington, Conn., superintendent; C. L. Ward, Portland, Me., superintendent meter department; North M. West, Kennebunk, Me., manager York Water Company; William Jay Willson, Greenwich, Conn., superintendent; F. R. Woodward, Hill, N. H., manager and owner water works; Edward Wright, Boston, Mass., civil engineer.

Non-resident: Roger W. Armstrong, New York, N. Y., engineer Board of Water Supply; A. C. Bingham, Marysville, Calif., manager water company; W. P. Brereton, Winnipeg, Manitoba, city engineer; D. A. Decrow, Buffalo, N. Y., mechanical engineer; William Flannery, Brooklyn, N. Y., mechanical engineer; Charles A. Furley, Pittsburgh, Pa., superintendent; Edgar B. Kay, Tuscaloosa, Ala., consulting engineer; Carlos Lobo, Brooklyn, N. Y., superintendent in charge of maintenance operation, extension and improvement of water supply system; John T. Metcalf, Brooklyn, N. Y., civil engineer; Armory G. Singletary, San José, Calif., director, Water Company; C. L. Scofield, Montreal, Canada, manager, Canadian Fire Underwriters Association; Linden C. Trow, Lake Forest, Ill., superintendent; J. A. Vertefeuille, Richmond Hill, N. Y., assistant engineer, Brooklyn Water Department. (70.)

Associate: The Smith & Abbott Company, Portland, Me. (1.)

They were by unanimous vote duly elected thereto.

EXECUTIVE COMMITTEE.

Meeting of the Executive Committee of the New England Water Works Association at headquarters, Tremont Temple, Boston, Mass., Wednesday, March 8, 1916.

Present: President William F. Sullivan and members Caleb M. Saville, Samuel E. Killam, D. A. Heffernan, R. C. P. Coggeshall, F. J. Gifford, Richard K. Hale, Lewis M. Bancroft, George A. King, and Willard Kent.

Five applications for active membership and one for associate were received and they were by unanimous vote recommended therefor.

W. B. Everett, manager Northwest Electric and Water Works, Montesano, Wash.; George W. Simons, Jr., assistant, Civil Engineering Department, Massachusetts Institute of Technology, 1075 Boylston St., Boston, Mass.; J. W. O'Neill, chief of Meter and Inspection Departments, City Hall, Montreal, Canada; Samuel M. Gray, designing, construction, and maintenance of water works and sewers and railroad work, Providence, R. I.; Samuel Dyer, civil engineer, Water and Sewer Department, city engineer, Attleboro, Mass. Associate: Central Brass Manufacturing Company, Cleveland, Ohio.

The place of holding the next Annual Convention was discussed without definite action.

The President appointed Messrs. Charles W. Sherman, Richard K. Hale, Samuel E. Killam, William E. Maybury, and F. J. Gifford a Committee of Arrangements for the June outing of the Association.

Adjourned.

Attest: WILLARD KENT, *Secretary.*

Meeting of the Executive Committee of the New England Water Works Association at headquarters, Tremont Temple, Boston, Mass., Wednesday, March 29, 1916.

Present: President William F. Sullivan, members Caleb M. Saville, Samuel E. Killam, D. A. Heffernan, R. C. P. Coggeshall, R. J. Thomas, F. J. Gifford, R. K. Hale, L. M. Bancroft, G. A. King, Willard Kent, and William S. Johnson, Leonard Withington, and Frank A. McInnes.

Mr. Leonard Withington, of Portland, Me., presented the advantages of that city as a place for holding the next Annual Convention, and, after discussion, on motion of Mr. Thomas, seconded by Mr. Coggeshall, it was unanimously voted, that the Annual Convention of the New England Water Works Association for 1916 be held at Portland, Me., September 13, 14, and 15.

On motion of Mr. Coggeshall, seconded by Mr. Thomas, it was unanimously voted, that the salary of Miss Ham, Assistant Secretary, be made eight hundred dollars for the current year, increase to date from January 1, 1916.

A report of progress was made by Messrs. Coggeshall and Johnson, of the Membership Committee.

On motion of Mr. King, it was voted, that the President and Secretary be a committee to investigate and report at the June meeting on the advisability of holding an October meeting in the western section of New England.

The President was authorized to appoint a committee of arrangements for the Annual Convention, said committee to have full powers.

The freedom of headquarters of this Association was granted members of the Vermont Society of Civil Engineers, the Boston Society of Civil Engineers having already taken similar action.

Adjourned.

WILLARD KENT, *Secretary.*

Meeting of the Executive Committee of the New England Water Works Association on steamer *Miles Standish*, Boston Harbor, June 21, 1916.

Present, William F. Sullivan, President, and members D. A. Heffernan, R. C. P. Coggeshall, F. J. Gifford, L. M. Bancroft, G. A. King, and Willard Kent.

Seventy-one applications were received, seventy for active and one for associate membership, as follows:

Frederic L. Andrews, Sanford, Me., superintendent; Frederick W. Bateman, Clinton, Mass., civil engineer; G. A. Bean, Derry, N. H., superintendent; George W. Bowers, Cleveland, Ohio, civil engineer; George F. Bourne, Lenox, Mass., water commissioner; Homer E. Bridge, Hazardville, Conn., manager and superintendent; James L. Bryne, Boston, Mass., construction engineer; John Byrne, Westbrook, Me., superintendent; B. R. Chapman, Brockton, Mass., city engineer; Guy H. Chase, Fitchburg, Mass., commissioner of streets and engineering; Joseph S. Craigue, Walpole, Mass., civil engineer; Charles W. Eddy, Thomaston, Conn., civil engineer; Charles W. Ellis, Jr., Mattapoisett, Mass., superintendent; Frank Emerson, Peabody, Mass., superintendent; Henry F. Frost, South Easton, Mass., treasurer; H. L. Foster, Boston, Mass., civil engineer; W. A. Gardner, Suffield, Conn., superintendent; Marshall R. Goding, Portland, Me., auditor; Pearl T. Gray, Portland, Me., registrar; J. Francis Granger, Marlboro, Mass., engineer; Jacob A. Handy, South Dartmouth, Mass., chairman water commissioners; George B. Hamblin, Whitinsville, Mass., purchasing agent; John V. Hazen, Hanover, N. H., instructor of engineering, Dartmouth College; Charles R. Hildred, Somerville, Mass., chief clerk, office of water department; Charles I. Hosmer, Turners Falls, Mass., hydraulic engineer; William L. Howard, Hingham, Mass.; William H. Jaques, Little Boar's Head, N. H., President Hampton Water Works Company; Minol S. Kaharl, West Somerville, Mass., clerk, Wiscasset Water Company; J. Frank Kidder, Burlington, Vt., superintendent; Godfrey Knight, Avon, Mass., superintendent; Beardsley Lawrence, Dorchester, Mass., civil engineer; Joseph F. A. Leonard, Fall River, Mass., civil engineer; Sheldon E. Minor, Greenwich, Conn., civil engineer; Morton L. Miller, Springfield, Mass., master mechanic, water works; Oren M. Moulton, Gorham, Me., consulting engineer; Hugh Nawn, Roxbury, Mass., civil engineer; Reeves J. Newsom, Lynn, Mass., superintendent; John E. Palmer, Boston, Mass., consulting engineer; John Parsons, Somersworth, N. H., superintendent; Stanley G. Proverbs, New Bedford, Mass., hydraulic engineer; Edwin L. Pride, Boston, Mass., accountant; Joseph B. Sando, Boston, Mass., mechanical engineer; Harry W. Sawyer, Manchester, N. H., civil engineer; Walter H. Sawyer, Lewiston, Me., hydraulic engineer; Warren J. Simonds, Marlboro, Mass., city engineer; George G. Shedd, Manchester, N. H., consulting engineer; A. H. Starkweather, Wakefield, Mass., superintendent; Ralph Sweetland, Boston, Mass., engineer, Insurance Exchange; Frederic H.

Taber, New Bedford, Mass., member water board; Alfred H. Terry, Bridgeport, Conn., city engineer; Alberti T. Thompson, Rockville, Conn., superintendent; Frank M. Travis, Torrington, Conn., superintendent; C. L. Ward, Portland, Me., superintendent meter department; North M. West, Kennebunk, Me., manager York Water Company; William Jay Willson, Greenwich, Conn., superintendent; F. R. Woodward, Hill, N. H., manager and owner water works; Edward Wright, Boston, Mass., civil engineer.

Non-resident: Roger W. Armstrong, New York, N. Y., engineer Board of Water Supply; A. C. Bingham, Marysville, Calif., manager water company; W. P. Brereton, Winnipeg, Manitoba, city engineer; D. A. Decrow, Buffalo, N. Y., mechanical engineer; William Flannery, Brooklyn, N. Y., mechanical engineer; Charles A. Furley, Pittsburgh, Pa., superintendent; Edgar B. Kay, Tuscaloosa, Ala., consulting engineer; Carlos Lobo, Brooklyn, N. Y., superintendent in charge of maintenance operation, extension and improvement of water supply system; John T. Metcalf, Brooklyn, N. Y., civil engineer; Armory G. Singletary, San José, Calif., director, Water Company; C. L. Scofield, Montreal, Canada, manager, Canadian Fire Underwriters Association; Linden C. Trow, Lake Forest, Ill., superintendent; J. A. Vertefeuille, Richmond Hill, N. Y., assistant engineer, Brooklyn Water Department. (70.)

Associate: The Smith & Abbott Company, Portland, Me. (1.)

They were by unanimous vote recommended therefor.

The committee appointed to consider the advisability of holding a meeting of the Association in October at some place in the western portion of New England reported the result of their investigation without recommendation, and the subject was referred to the September meeting of the Executive Committee.

The advisability of the appointment of a committee to consider the subject of Rates for Fire Protection, and to report thereon, was discussed, and it was voted that the matter be brought to the attention of the Association.

Voted, That the President be authorized to appoint a committee on Form of Statistics of Assets, should he deem it desirable.

Adjourned.

WILLARD KENT, *Secretary.*

715 TREMONT TEMPLE, BOSTON, MASS., April 7, 1916.

A meeting of the Committee of Arrangements for the 1916 Annual Convention of our Association was held at headquarters, Boston, on Friday, April 7, 1916.

The meeting was called to order at 11 o'clock A.M., Chairman William S. Johnson presiding. There were present, President Sullivan, of Nashua, N. H.; James Burnie, of Biddeford, Me.; and Secretary Kent; William F. Woodburn was also present, bearing a letter of authorization from Mr. James W. Graham, of Portland, Me., who was unable to be present, and acted as his substitute.

Mr. Johnson read a letter from Mr. W. S. Garde, of Hartford, Conn., regretting that business of the City of Hartford called him to Washington, D. C., and thereby prevented his meeting with the committee. Messrs. Charles W. Sherman and Frank A. Barbour were also present and acted with the committee at the request of Chairman Johnson.

The organization of the committee was completed by the election of Mr. Graham as secretary and Mr. Vernon F. West as treasurer. Mr. Willard Kent was elected secretary pro tem. of the committee.

A general discussion of hotel accommodations, entertainment, financial matters, etc., was held, after which the following named action was taken:

Voted, That Messrs. James W. Graham and Vernon F. West be and are hereby appointed a committee on finance.

Voted, That Messrs. William S. Johnson, Frank A. Barbour, and Charles W. Sherman be and are hereby appointed a committee to secure papers for presentation at the convention.

Voted, That Messrs. James W. Graham, James Burnie, and Vernon F. West be and are hereby appointed a committee on entertainment for the convention.

Voted, That Mr. William S. Johnson, chairman, be empowered to make any further arrangements necessary, in his judgment, for the success of the convention.

Adjourned, subject to the call of the chair.

WILLARD KENT, *Secretary pro tem.*

Annual Convention to be held in Portland, Maine
September 13, 14 and 15, 1916.

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OFFICERS

OF THE

New England Water Works Association

1916.

PRESIDENT.

WILLIAM F. SULLIVAN, Engr. and Supt., Pennichuck Water Works, Nashua, N. H.

VICE-PRESIDENTS.

CALEB M. SAVILLE, Chief Engr., Bd. Water Commissioners, Hartford, Conn.
CARLETON E. DAVIS, Chief, Bureau of Water, Philadelphia, Pa.
SAMUEL E. KILLAM, Supt. Pipe Lines and Reservoirs, Metropolitan Water Works, Boston, Mass.
R. S. LEA, Civil and Hydraulic Engineer, Montreal, Canada.
D. A. HEFFERNAN, Supt. Water Works, Milton, Mass.
WILLIAM W. BRUSH, Deputy Chief Engr., Bureau of Water Supply, New York, N. Y.

SECRETARY.

WILLARD KENT, Civil Engineer, Narragansett Pier, R. I.

EDITOR.

RICHARD K. HALE, Civil Engineer, 85 Water Street, Boston, Mass.

TREASURER.

LEWIS M. BANCROFT, Supt. Water Works, Reading, Mass.

ADVERTISING AGENT.

GEORGE A. KING, Supt. Water Works, Taunton, Mass.

ADDITIONAL MEMBERS OF EXECUTIVE COMMITTEE.

R. C. P. COGGESHALL, Supt. Water Works, New Bedford, Mass.
ROBERT I. THOMAS, Supt. Water Works, Lowell, Mass.
F. J. GIFFORD, Supt. Water Works, Dedham, Mass.

FINANCE COMMITTEE.

GEORGE H. FINNERAN, Asst. Supt. Water Service, Boston, Mass.
D. N. TOWER, Supt. Water Co., Cohasset, Mass.
JOHN MAYO, Supt. Water Works, Bridgewater, Mass.

THE ASSOCIATION was organized in Boston, Mass., on June 21, 1882, with the object of providing its members with means of social intercourse and for the exchange of knowledge pertaining to the construction and management of water works. From an original membership of only TWENTY-SEVEN, its growth has prospered until now it includes the names of over **900** men. Its membership is divided into two principal classes, viz.: MEMBERS and ASSOCIATES. Members are divided into two classes, viz.: RESIDENT and NON-RESIDENT, — the former comprising those residing within the limits of New England, while the latter class includes those residing elsewhere. The INITIATION fee for the former class is FIVE dollars; for the latter, THREE dollars. The annual dues for both classes of Active membership are THREE dollars. Associate membership is open to firms or agents of firms engaged in dealing in water-works supplies. The initiation fee for Associate membership is TEN dollars, and the annual dues FIFTEEN dollars. This Association has six regular meetings each year, all of which, except the annual convention in September, are held in Boston.

New England Water Works Association.

ORGANIZED 1882.

Vol. XXX. September, 1916. No. 3.

This Association, as a body, is not responsible for the statements or opinions of any of its members.

PROGRESS OF WATER DISINFECTION IN MARYLAND.

BY ROBERT B. MORSE, CHIEF ENGINEER, AND HARRY R. HALL, ASSISTANT CHIEF ENGINEER, MARYLAND STATE DEPARTMENT OF HEALTH.

[*Read February 9, 1916.*]

There are eighty-three public water supplies in Maryland, serving about 842 500 people, — 62.1 per cent. of the estimated total population of 1 357 374. Several community systems delivering water to small groups of houses, and also institutional supplies, are not included in this number.

The state, through its Board of Health, has had, since 1914, strict supervisory control over the design, construction, and operation of water systems. No material extensions of, nor alterations in, existing systems can be legally made, nor can new supplies be installed, unless complete plans and specifications covering the proposed work are submitted to the State Board of Health for approval and a written permit is granted by that body. Moreover, when deemed necessary for the public health or welfare, the Board may require existing water systems extended or altered, and it is empowered to compel the installation of public supplies in communities not served. It is the duty of the corporate officers to raise the funds necessary for carrying out the work required, and they may do this, if they wish, by issuing bonds without special legislative enactment and without a referendum vote.

Broad as is the control of the state over the design and construction of water supplies, it is no more liberal than is its authority

over the operation of existing systems, in so far as the public health is affected. If the State Board of Health finds that any water plant is not properly operated, it may require a change of method, and may, when necessary, force the employment of competent attendants, it even being enabled to attain this end by appointing attendants of its own selection, at the cost of the municipality or water company owning the plant. Possible arbitrary action, however, is precluded by a provision in the law allowing appeal to the local county court, before which the Board would have to prove the reasonableness of its act.

Prior to the passage of the law giving the State Board of Health such complete power over water supplies, there was no legislation which specifically enabled it to compel necessary improvements. The laws existing before 1914 merely conferred the right to investigate and report upon water systems. There was one provision which made it a misdemeanor to pollute sources of water supply, and imposed penalties for offenses of this character, but there was nothing which actually gave the Board the power to force a municipality or water company to provide a safe water supply.

The engineering division of the State Board of Health was organized in June, 1912, under a law passed in 1910, which also provided for the formation of several other divisions. This act prescribed general duties of investigation, as mentioned above. The early engineering studies indicated plainly the need of complete supervisory power over the water supplies of the state, and this need was satisfied by the passage of the water supply and sewerage act of 1914.

An effort has been made by the State Board of Health to use its power in a judicious manner and not to attempt coercive measures where proper improvements could be brought about in other ways. It has not yet been necessary to invoke the full extent of its legal power, and in no case has the Board been compelled to appoint operating attendants for water supplies which have been improperly cared for, although in some instances this might well have been done.

In 1912, when the engineering investigations were begun, it was found that, in general, knowledge of the condition of the public

water supplies in the state was meager. Analyses of the water from many of the supplies had been made occasionally, but no systematic method of examination had been followed. The Baltimore system was looked after by the city water and health departments, and consequently received little or no attention from the State Board of Health.

The state's investigations commenced to show that many of the water systems were badly in need of attention. The surface supplies were derived from streams fed by watersheds containing habitations, in many cases providing numerous sources of contamination, and, in general, protection was not offered by long storage, filtration, or other treatment. Water was usually taken from the stream at an intake dam, and passed into a distributing reservoir of insufficient capacity to provide a safe period of storage. Moreover, water from some of the tubular well systems was found to be polluted, because the wells either were of too shallow depth and located in the midst of thickly settled districts where sources of pollution were numerous, or were driven in rock containing fissures. Some supplies previously considered to be beyond suspicion were found, upon close investigation, to be in a bad condition and a menace to the public health.

In a large number of the instances where supplies were polluted, the water was satisfactory from a physical standpoint, there being an absence of color, turbidity, and other objectionable characteristics. This was naturally true in the case of most well and spring waters. The water from streams fed by mountain watersheds, and from watersheds containing much wooded or uncultivated land, was also generally in good physical condition.

Where water, otherwise acceptable, was found to be in an unsafe sanitary condition, filtration did not appear to be necessary or even advisable for assuring the proper degree of purity. Expense and the improbability of proper operation are two factors which would make filtration plants undesirable for many of the small systems which abound in Maryland. Consequently, disinfection was resorted to wherever it would serve the purpose. There were, however, a considerable number of surface supplies derived from streams flowing through cultivated country and furnishing a water occasionally or persistently turbid. Such supplies as these natu-

rally require filtration. Disinfection in connection with filtration is general, and is required in all new installations. While the writers' assistants have been able to obtain good results from several filter plants without the addition of disinfectants, the character of attention which small works ordinarily receive makes their use essential.

Prior to the establishment of the engineering division of the State Board of Health, in 1912, there were only four disinfecting plants in operation on water supplies in Maryland. Two of these were located on the Gunpowder and Jones Falls systems, of Baltimore; and two, owned by the Baltimore County Water and Electric Company, were at the Avalon and Herring Run plants which serve large sections in Baltimore County near the city. At Avalon, disinfection was carried on in conjunction with filtration. All these installations used hypochlorite of calcium, and at Herring Run ozone was employed at times.

Since 1912, many towns in other parts of Maryland have been provided with purification plants, and it is a striking fact that, of the 842 565 persons served by public water supplies at the present time, 745 149, or 88.4 per cent. (approximately 54.9 per cent. of the population of the state), use water which is treated by either filtration or disinfection, or both.

The number of public systems in the state using raw, filtered, or disinfected ground and surface water, and the total populations of the communities served, are shown by Table 1.

There are eighty-three public water supplies in Maryland, sixty-one of which derive their water from underground sources. The population thus served amounts to 102 099. The number of consumers is small in comparison with the number of systems, because these supplies, in general, are located in the smaller towns. The remaining twenty-two systems take water from surface streams and serve a population of 740 466. The large population using surface water is accounted for by the fact that Baltimore and most of the other places of considerable size are thus supplied. Ground waters are used by 12.1 per cent. of the people served by public systems, and by 7.5 per cent. of the total population of the state. The corresponding figures for surface waters are 87.9 and 54.6 per cent.

TABLE 1.—CLASSIFICATION OF PUBLIC WATER SUPPLIES IN MARYLAND.

Untreated.				Treated.				
Number of Supplies	Population of Communities Served.	Per Cent. of Total Population of State.	Per Cent. of Population Using Public Supplies.	Form of Treatment.	Number of Supplies.	Population of Communities Served.	Per Cent. of Total Population of State.	Per Cent. of Population Using Public Supplies.
				Ground-Water Supplies.				
55	85 815	6.3	10.2	Disinfected only	5	10 284	0.8	1.2
				Filtered only	1	6 000	0.4	0.7
				Total treated	6	16 284	1.2	1.9
				Surface-Water Supplies.				
7	11 601	0.9	1.4	Disinfected only	9	76 916	5.7	9.1
				Filtered and disinfected	4	645 760	47.6	76.7
				Total disinfected	13	722 676	53.3	85.8
				Total filtered only	2	6 189	0.4	0.7
				Total treated	15	728 865	53.7	86.5
				All Supplies.				
62	97 416	7.2	11.6	Disinfected only	14	87 200	6.5	10.3
				Filtered and disinfected	4	645 760	47.6	76.7
				Total disinfected	18	732 960	54.1	87.0
				Total filtered only	3	12 189	0.8	1.4
				Total treated	21	745 149	54.9	88.4

Total population served by public water supplies.......... 842 565
Total population of state.......... 1 357 374

Of the ground-water supplies, six are treated, while of the surface supplies only seven deliver untreated water, and these to only 11 601 people. The six plants for purifying ground water serve 16 284 persons, and communities with a total population of 728 865, supplied by fifteen systems, are using treated surface water. There are eighteen public supplies with disinfecting plants, and three in which the water is filtered but not disinfected. A population of 732 960 is served with disinfected water, 12 189 with water filtered only, and 97 416 use raw water. Thus, 54.1 per cent. of the total population of Maryland drink disinfected, 54.9 per cent. treated, and only 7.2 per cent. raw, water. Of the total number of people served by public water systems, 87.0 per cent.. use disinfected, 88.4 per cent. treated, and 11.6 per cent. raw, water.

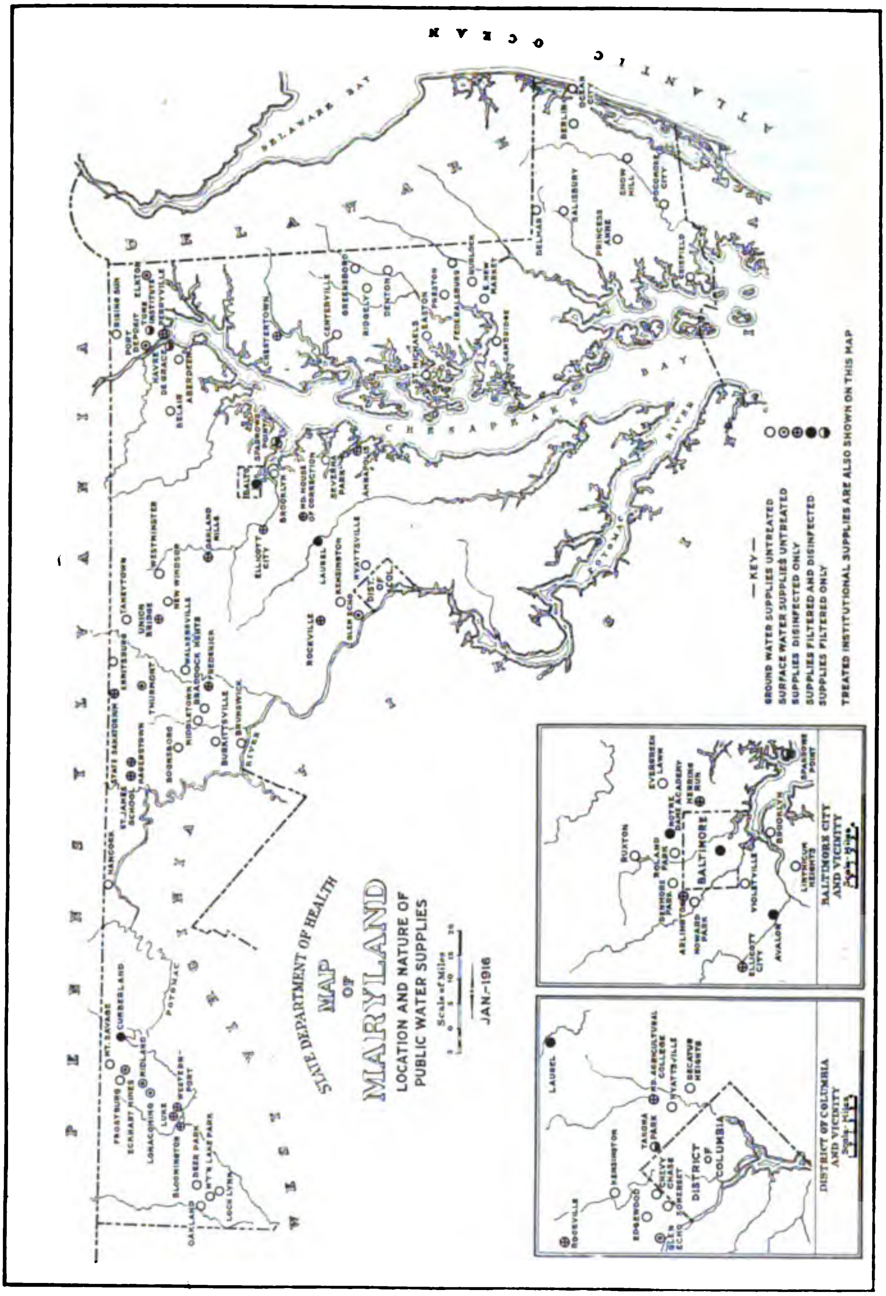
Not only is the influence of water purification felt by the public water supplies, but it has reached to state and private institutions as well. There are, as shown by Table 2, six institutions, embracing a population of 2 352, where the water receives treatment of some kind, and in all but one of these it is disinfected. Included in this number are a penal institution, a tuberculosis sanatorium and four educational institutions.

TABLE 2.

CLASSIFICATION OF TREATED INSTITUTIONAL WATER SUPPLIES IN MARYLAND.

Class.	Form of Treatment.	No. of Supplies.	Population Served.
Ground water	Disinfected only	2	652
Surface water	Disinfected only	2	1 100
	Filtered and disinfected	1	350
	Filtered only	1[1]	250
All supplies treated		6	2 352
Disinfected supplies		5	2 102

The location and nature of the public water systems and treated institutional supplies are shown in Fig. 1. The universal use of ground-water sources, and the consequent scarcity of purification works, in the section of the state east of Chesapeake Bay, is notable.



STATE DEPARTMENT OF HEALTH
MAP
OF
MARYLAND
LOCATION AND NATURE OF
PUBLIC WATER SUPPLIES
Scale of Miles
JAN.-1916
— KEY —
GROUND WATER SUPPLIES UNTREATED
SURFACE WATER SUPPLIES UNTREATED
SUPPLIES DISINFECTED ONLY
SUPPLIES FILTERED AND DISINFECTED
SUPPLIES FILTERED ONLY
TREATED INSTITUTIONAL SUPPLIES ARE ALSO SHOWN ON THIS MAP
BALTIMORE CITY AND VICINITY
DISTRICT OF COLUMBIA AND VICINITY
CHESAPEAKE BAY
DELAWARE BAY
ATLANTIC OCEAN

FIG. 1.

Disinfection by means of hypochlorite of calcium or liquid chlorine is naturally the most common method practiced, although one small mill town uses distilled water, which is the condensed exhaust from the steam turbines in the mill, and there is an ozone plant which is operated in conjunction with one of the hypochlorite installations. There is a possibility that ultra-violet ray disinfection will shortly be introduced, as its use is under consideration for a mechanical filter plant now being constructed.

The type of apparatus suitable for hypochlorite or liquid chlorine treatment in any particular case depends upon the method by which water is supplied. Where the flow of water to be treated is at most times substantially uniform, as in the case of certain pumping plants, or in gravity lines discharging into reservoirs, a manually controlled apparatus is sufficient. Where fluctuations occur in the rate of flow, automatic control devices are essential for proper results. Liquid chlorine plants, so-called, introduce chlorine into the water either as a gas or in solution. The gas feed, usually called " direct feed," is well adapted for use where no water under pressure, for dissolving the gas, can be easily obtained. There are no direct-feed plants in Maryland at the present time, and only one, at Perryville, is regulated automatically, although automatic equipment is about to be furnished at Frederick.

The early disinfecting plants, as stated previously, all made use of hypochlorite of calcium, and with effective results. Those on the Avalon and Herring Run supplies of the Baltimore County Water and Electric Company were the first to be installed in the state. The former was constructed in 1908, and the latter during the year following. Late in 1910 the Jones Falls supply for Baltimore was first disinfected, and in June, 1911, the Gunpowder River plant was put into use. Until 1913 these were the only installations of disinfecting apparatus used for water purification in Maryland. A filtration plant had been previously built by the Washington County Water Company, to supply Hagerstown from Antietam Creek during dry periods, and hypochlorite dosing apparatus had been provided; but the disinfectant was not used until the summer of 1913. About the same time, the State Board of Health constructed a plant for the Ellicott City system. Cumberland next followed, during the fall of the same year, by putting

into operation a hypochlorite plant in conjunction with the mechanical filters on its new supply. In December, the mountain supply of Hagerstown was furnished with hypochlorite apparatus. A typhoid fever epidemic at Rockville during February, 1914, made necessary the construction of an emergency hypochlorite plant by the State Board of Health, for treating the supply derived from tubular wells driven in rock and proven to be the cause of the disease. The first liquid chlorine apparatus was put into operation at Union Bridge in January, 1914, for treating about 120 000 gal. of water derived from tubular wells driven in limestone rock. An ozone plant had been installed in 1909 at the Herring Run supply of the Baltimore County Water and Electric Company, but at first it was used, so the writers are informed, only experimentally.

After the powers of the State Board of Health were broadened, in 1914, and an increased appropriation was provided for sanitary engineering work, water purification plants were naturally introduced at a more rapid rate than previously. At the present time there are eleven liquid chlorine installations treating about 5 600-000 gal. of water daily, and eleven hypochlorite plants treating approximately 90 600 000 gal. daily. Of the latter amount, eighty million gallons are delivered to Baltimore City.

Data concerning the disinfecting plants in Maryland are shown in Table 3.

Changes are taking place continually in the water supply situation in this state, and it is expected that the number of disinfecting plants soon will be increased and that alterations will be made in some of the water supplies, which will involve plants now in operation. At Annapolis the existing liquid chlorine plant probably soon will be used in conjunction with a mechanical filtration plant, the construction of which is contemplated, and at the Maryland House of Correction the liquid chlorine apparatus already installed will supplement purification by slow sand filters which were recently designed by the writers, and which will soon be built. A filtration plant is being constructed at Westminster, and one is being designed for the Springfield State Hospital. Liquid chlorine probably will be used for both of these installations. Liquid chlorine will soon replace hypochlorite at Westernport, and the

TABLE 3.

Data Concerning Water Supply Disinfecting Plants in Maryland.

Place.	Population (Estimated 1916).	Type of Plant.	Character of Supply.	Date.	Average Amount Treated Daily (Gallons).	Chlorine. Parts per Million.	Where Chemical is Applied.	Character of Attention.
Plants for Disinfection Only.								
Annapolis	8 656	Liquid chlorine	Surface	1915	1 224 600	0.32	Pump suction	Good.
Arlington	5 250	Liquid chlorine	Ground	1914	72 000*	0.30	Pump suction	Indifferent.
Bloomington	372	Liquid chlorine	Surface	1915	15 000	...	Supply main	Not yet in continuous operation.
Chestertown	2 730	Hypochlorite	Ground	1915	170 000	0.23	Pump suction	Good.
Ellicott City	1 148	Hypochlorite	Surface	1913	70 000	...	Pump suction	Neglected — used only occasionally.
Frederick	11 056	Liquid chlorine	Surface	1915	1 000 000	0.36	Supply main under pressure	Indifferent.
Hagerstown	25 500	Hypochlorite† Liquid chlorine	Surface	1913 1914	2 500 000	0.44 0.40	Before entering supply main	Good.
Herring Run (Baltimore County)	25 493	Hypochlorite Ozone	Surface	1909 1909	2 800 000	0.40	Pump well	Good.
Luke	950	Distillation	Surface	1912	150 000	Water is condensed exhaust from steam turbines in mill of W. Va. Pulp and Paper Co.		
Maryland Agricultural College	300	Hypochlorite	Surface	1916	30 000	...	Pump suction	Not yet in full operation.
Maryland House of Correction	800	Liquid chlorine	Surface	1915	200 000	0.60	Pump suction	Intermittent — much better than at first.
Maryland Tuberculosis Sanatorium	600	Hypochlorite† Liquid chlorine	Ground	1915 1915	90 000	0.89 0.67	Pump suction	Good.

Oakland Mills	200	Hypochlorite	Ground	1915	9 000	0.83	Storage tank	Neglected — used only occasionally.
Perryville	632	Liquid chlorine	Surface	1915	300 000	0.50	Supply main	Indifferent.
Rockville	1 221	Liquid chlorine	Ground	1916	30 000	0.22	Collect. res.	Good.
St. James School	52	Hypochlorite	Ground	1915	4 000	1.50	Storage tank	Good.
Union Bridge	883	Liquid chlorine	Ground	1914	120 000	0.35	Pump suction	Good.
Westernport	3 109	Hypochlorite	Surface	1914	450 000	0.40	Intake at dam*	Neglected at first, at present good.
Plants for Filtration and Disinfection.								
Avalon (Baltimore County)	30 197	Hypochlorite	Surface	1908	1 500 000	0.80	Outlet of coagulating basin	Good.
Baltimore City	587 112	Hypochlorite	Surface	1915	80 000 000	0.30‡	Filtered water	Good.
Cumberland	25 843	Hypochlorite	Surface	1913	5 500 000	0.20	Inlet to coagulating basin	Good.
Laurel	2 608	Hypochlorite	Surface	1915	70 000	....	Filtered water	Not yet in continuous operation.
Notre Dame	350	Liquid chlorine	Ground	1915	30 000	0.25	Pump suction	Good.

* This amount is mixed with raw water from other sources.

† Now kept for emergency use.

‡ As high as 3.0 parts per million of available chlorine have been used in treating the raw water before the filtration plant was installed.

same change is being considered for the Baltimore filtration plant, for which hypochlorite was recently quoted at $290 a ton, on the basis of a yearly contract. There is a marked tendency to use liquid chlorine instead of hypochlorite of calcium in connection with old as well as new installations, and the high price which now has to be paid for the latter will stimulate this movement.

The amount of chemical used at the disinfecting plants in Maryland has varied widely according to local conditions. It has ranged from 0.2 to 3.0 parts per million of available chlorine in the case of hypochlorite treatment, and from 0.25 to 0.67 parts where liquid chlorine is used. Where the disinfectant is applied to a spring or well water, or to the effluent from a well-operated filtration plant, the amount required is usually near the minimum mentioned above. In the case of turbid waters, larger amounts have been found necessary for proper treatment, and at times of extreme turbidity excessive quantities are required. In the treatment of the Baltimore City water, as high as 3 parts per million of available chlorine, or 75 pounds of hypochlorite to the million gallons, have been used on raw water. The amount necessary in many instances depends also upon the character of attention given the apparatus.

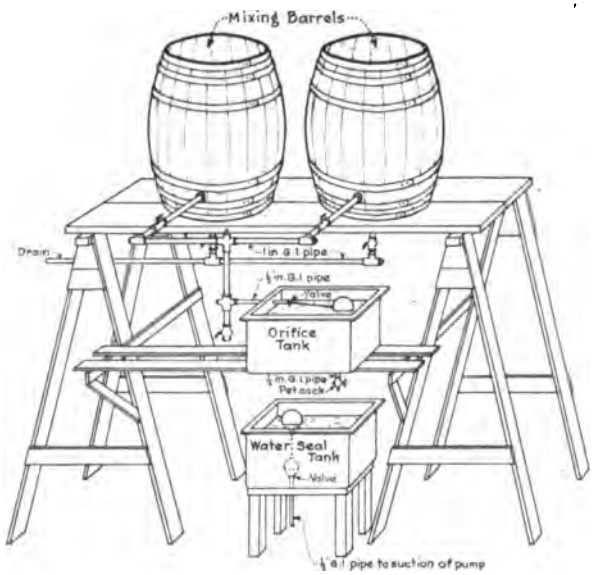
It is by no means a fact that the disinfecting plants in Maryland have been operated with complete satisfaction, for most of them have had trouble of some kind. The difficulties encountered could generally have been avoided with more attention to proper operation. With hypochlorite plants, the principal annoyance has been due to the formation of coatings which clog the pipes; and, where the solution was particularly strong, the materials of which the piping was made have been attacked, necessitating the replacement of parts. These are not serious troubles, however, and can be eliminated by frequent inspection. In the case of liquid chlorine plants, it has been found that occasionally a part becomes corroded and requires replacement, or a valve gets out of adjustment, but the gradual perfection of apparatus is making such occurrences less frequent.

Where faithful and intelligent attention has been given to operation, and the amount of disinfectant used has not been excessive, few complaints have been made regarding tastes or odors in the

water. In one instance, where a liquid chlorine plant of the manual control type was disinfecting water the flow of which fluctuated considerably, there was always an overdose at night which caused complaint due to tastes noticeable during the early hours of the day. This, of course, was the fault of the method employed and not of the treatment itself. In general, fewer complaints have been registered concerning disagreeable tastes where liquid chlorine was used than in the case of hypochlorite.

There has been a marked decrease in the prevalence of typhoid fever in some of the communities where disinfecting plants have been installed. In most cases, however, the period of operation has been so short, and, on account of the small size of some of the places, the appearance of typhoid so irregular, that records do not indicate clearly the effect produced. Moreover, much of the typhoid fever in Maryland is attributable to causes other than impure water supplies. Nevertheless, there are certain well-defined instances where a decrease in typhoid fever morbidity and mortality can be traced directly to purification of a water supply. In Baltimore, the reduction has been very pronounced. After the disinfecting plants were built, the prevalence of typhoid immediately fell off, and the improvement has since continued. In 1915, both the morbidity and mortality rates from this disease, although higher than in many of the larger cities of the country, were approximately half as great as in 1910. Following the introduction into Cumberland of filtered and disinfected water from Evitts Creek, in place of the former raw supply from the Potomac River, the occurrence of typhoid fever was so reduced that, in 1915, there were scarcely more than one sixth as many cases of, and one fifth as many deaths from, this disease as in 1913, in spite of the fact that the corporate limits had been enlarged in the meantime. However, the change in source, and the long storage period provided in the reservoir, would undoubtedly have caused a large proportion of this improvement without the presence of a purification plant. One of the most striking instances of the effect upon typhoid occurrence, caused by disinfecting a water supply in Maryland, was that of the Rockville epidemic, which, after twenty-eight cases had occurred, was checked suddenly by the installation of an emergency hypochlorite plant.

**EMERGENCY HYPOCHLORITE PLANT
USED BY MARYLAND STATE DEPARTMENT OF HEALTH
FOR DISINFECTING WATER SUPPLIES**



LIST OF MATERIAL

2 – Clean watertight barrels
Several feet of 1 in. and ½ in. galvanized iron pipe and tools for cutting and threading
5 – 1 in. valves
4 – 1 in. "T" branches
1 – 1 in. x ½ in. cross or 4 way fitting
4 – Locknuts to attach 1 in. pipe to barrels
1 – 1 in. cross or 4 way fitting
4 – 1 in. pipe plugs
1 – ½ in. pipe plug
1 – ½ in. pet cock
1 – Watertight tank, preferably lead lined, with valve, and float control which opens valve as water level drops. An apparatus of this type easily obtained is a flush tank for a toilet.
1 – Lead-lined watertight tank with valve, and float control which closes valve as water level drops. This is necessary only where disinfectant is introduced into suction of pump.

FIG. 2.

In order that prompt remedial measures may be instituted when a water supply is at any time found to be in an unsafe condition,

or when an outbreak of typhoid fever casts suspicion on a water previously untreated, the engineers of the State Board of Health are all instructed in the setting up of an emergency hypochlorite dosing apparatus, making use of ordinary and easily obtainable materials. A sketch showing the general arrangement of the device used, including a bill of material, has been prepared, and is usually sent ahead, so that the necessary material may be on hand when the engineer arrives at his destination. This apparatus, shown on Fig. 2, has proven its value on many occasions, and several of the installations are still in operation.

Basing judgment on experience in Maryland, it may be stated that, where chlorinating plants for water supplies are given faithful and intelligent attention, their use is decidedly a success; and they provide an effective and inexpensive method for treating many water supplies which do not need filtration, as well as for safeguarding those supplies for which filtration, although desirable, is prohibitive. Unfortunately, there seems to have been some tendency among manufacturers to convey the impression that little attention need be paid to the operation of a liquid chlorine plant. This has given the operator the impression, in some instances, that the apparatus can be entirely neglected. While it is true that little or no difficulty need be experienced, except when parts give out, neglect is certain to cause irregularity in dosing, exposure in certain cases to freezing and other undesirable results. Greater efficiency from some of the disinfecting plants in Maryland is to be expected in the future, as the State Board of Health will be enabled to make more frequent inspections than in the past. This will be made possible by the fact that, in addition to the main office of the engineering division, there are maintained four offices in various parts of the state, at each of which there is a resident engineer who has direct supervision over sanitary engineering matters in his district. Without an effective system of control, disinfection would fall short of giving entire satisfaction in connection with many small water supplies.

DISCUSSION.

MR. HARRY W. CLARK.* The disinfection of water by hypochlorite is, of course, an old thing at the present time, and hypochlorite when properly and continuously applied in sufficient amounts is a good disinfectant and kills a very large proportion of of the bacteria in water, especially in clear water. However, in Massachusetts, as you know, most of our surface waters are stored waters, and we depend largely upon storage for purification, although there are quite a number of filters in the state, of one kind or another. I think there are twenty-eight filters in Massachusetts at the present time, and only one place where liquid chlorine or hypochlorite is being used, that place being Wakefield.

We have very little call for the use of disinfectants in connection with water supplies. As you all know, the State Board of Health was changed to a Department of Health rather more than a year and one-half ago, and one of the first orders of the new department was to make and have ready a hypochlorite plant for emergency use, to rush out wherever an epidemic of typhoid fever, due to a polluted water supply, was occurring or was imminent. This plant has been in one of the storerooms of the laboratory for fourteen months without an emergency call of that nature arising, and I trust that it will remain there another fourteen months without being called for.

In a state like Maryland, and in many states where the care and supervision of water supplies is a new thing and where a great many supplies are taken from sources such as described in this paper, I think the use of hypochlorite or liquid chlorine is entirely justified, and I have no doubt it has cut down typhoid fever in places in Maryland. But, as I say, we have had very little use for it in Massachusetts. I have nothing to say against disinfection. When and where it is necessary, I believe in it.

The paper spoke of disinfection by ultra-violet rays, and for the past year and one-half we have had an ultra-violet ray plant in operation at the Lawrence Experiment Station, testing its efficiency with both turbid and clear waters. Judging from the results of our tests, this method of sterilization is more costly

* Chemist, State Department of Health, Boston.

and with us not as efficient as liquid chlorine or hypochlorite. Still, it is an interesting process, and the class of men working upon its improvement will probably lessen its cost and increase its efficiency. I understand that at Ottawa very good results have been obtained from the experiments carried on there, and these results are better than those we have obtained at Lawrence. However, they may have a clearer water. If the water is slightly turbid, the ultra-violet ray seems to have very little efficiency.

I have investigated the use of ozone, and have visited ozone plants abroad and one or two in this country. They seem able to work them abroad successfully, but, I believe, at a considerable expense. At one plant I visited in this country, where it was said ozone was being used and good results obtained, there was a marked odor of hypochlorite around the plant, and evidently it was being used; in fact, I do not think ozone was doing the work, but an abundant supply of hypochlorite was. One could taste it in the water and, as I said, smell it around the plant. This is also a very interesting process, and I hope, as I do in regard to the ultra-violet ray, that it will eventually be more universally successful and of low cost.

EXPERIENCE WITH WOOD PIPES IN NEW HAMPSHIRE.

BY ARTHUR W. DUDLEY.*

[*Read November 10, 1915.*]

Wood pipe for centuries has been in use as a means for conveying water and was one of the earlier materials used for this purpose. The Romans used it for generations, substituting it for the old sheet lead pipes that were used in their first aqueducts. The first water supply of London had lead and wood mains, and the latter eventually replaced all of the lead pipes. Some of their old wooden pipes have been lately removed from the London streets and all were found to be in a perfect state of preservation. In our older American cities, New York, Philadelphia, Boston, Portsmouth, N. H., and others, it was used in their first systems, and at the present day is removed in a perfect state of preservation. The writer has in his office a section dug up in Bowdoin Square in Boston during the excavation for the subway that is as sound as when cut from the forest. It is of solid white oak timber 10 in. outside diameter, of octagonal form, with an inside bore of 4 in. This was a part of Boston's first water system, laid more than two hundred years ago. The water was taken from a pond on Beacon Hill, and was abandoned in 1814, when an extension to the State House occupied the ground covered by this pond.

The writer several years ago saw one of the ancient pipe lines at Portsmouth, N. H., dug up that consisted of pine logs with a 3-in. bore and found the entire line uncovered as sound and in as good condition for conveying water as when laid. This pipe line must have been laid for two hundred years or more. At Exeter, N. H., a wood pipe aqueduct was used up to the installation of their present water system in 1886, and had given good service for nearly one hundred years. These pipes when encountered in street excavations are invariably found to be entirely free from decay. These ancient wooden water pipes were bored logs, and in their manufacture the very best part of the

* Of Dudley & Sawyer, Manchester, N. H.

timber, namely, the heart was removed. It may be asked why, if wood pipe was so durable, should cast iron or any other material be substituted? The answer to that question is that the old method of making a wood pipe limited its inside diameter to the size of the log, and, therefore, large pipes were both expensive and usually impracticable; 6 in. inside diameter was nearly the limit of such pipe. By the modern method of making wood pipe the diameter is practically unlimited, and it has been made in the continuous form up to ten feet in diameter.

The two forms of wood pipe in common use are, the continuous pipe, built of staves, breaking joints, put together in the trench, and what is termed "machine made." This latter is made in lengths from 3 to 14 ft., and shipped to the work ready to be laid. The staves are about 2 in. in thickness, are cut true to the circle of the diameter of the pipe. These staves have two beads upon each longitudinal edge, and two corresponding grooves in the other longitudinal edge. The beads are slightly larger than the grooves and when pressed together the bead crushes into the groove, this making it perfectly watertight. At one end there is a tenon 4 in. long where the staves are one half the thickness of the balance of the walls of the pipe. On the other is a chamber cut 4 in. deep. The tenon is slightly smaller in diameter at the end than at the shoulder so that when driven into the chamber it makes a watertight joint. These staves, cut radially to correspond with the diameter of the pipe, are held together by a steel band, either flat or round, wound spirally upon the pipe by a machine. The high tension of this band forces the beads into the grooves, making a longitudinal joint that cannot leak so long as the elastic limit of the bands is not overcome. After the pipe is wound, and the tenon and chamber cut, it is rolled in a bath of asphalt that adheres to the outside of the steel and wood, protecting them from oxidation. Usually a second coating of asphalt is applied. It is then rolled in a bed of sawdust that forms a protection for it in shipping and handling. It is laid by driving one piece into another until the shoulders are in close contact. This form of pipe is made for diameters from 3 to 36 in.; the larger pipes are made in the continuous form. The eastern manufacturers make their pipes of the best obtainable

Canadian pine. The Pacific Coast pipe is made of Douglass fir and redwood, and is banded with round steel wire instead of flat steel, and differs also in that the pipes are all made with tenon ends, that are connected with sleeves 6 to 8 in. in length. The manufacturers claim that this method of connecting gives greater strength to the pipe line, and also that Douglass fir and redwood is a stronger material than pine. The writer, however, after experimenting with both forms of pipe, came to the conclusion that while the claim that the sleeve method of connection may be stronger, the difficulty in coating the exposed ends of these sleeves, and the fact that they would not be saturated at all times, exposed them to greater danger from decay. Also that while Douglass fir might and probably does possess greater tensile and crushing strength than pine, still its greater brittleness exposes it to more danger from water hammer, and for these and other minor reasons has given the preference to the tenon and chamber, flat hooped pipe. This form of wood pipe was first laid in New Hampshire in 1895 at Penacook, a suburb of Concord, and this system was afterwards connected with and incorporated into the Concord water system. The Antrim water system, constructed in 1896, is a gravity system; its source of supply is Campbell's Pond, some three miles from the village, and the head is slightly over 200 ft. The entire system, both supply and distribution pipes, is of wood. The writer on several occasions during the past few years has uncovered and examined pipes in this water system, and has invariably found them as perfect as when laid; the leakage here, as in all wood pipe lines that he has had to do with, is infinitesimal.

Other water systems, most of them designed and constructed by the writer, are,—Campton Village, where the bead is 186 ft. and the supply pipe 12 in. and 10 in., the distribution pipe, 8 in. and 6 in. in diameter; this was constructed in 1905. Freedom, N. H., constructed in 1912, with a head of 300 ft. Both of these systems have no apparent leaks and have cost next to nothing for repairs since their installation. Bristol, N. H., has a 20-in. wood pipe supply line connecting the village distribution system with New Found Lake, the source of supply. Laconia, N. H., has a wood pipe intake line laid 400 ft. into Lake Winnepesaukee, connecting with

the pumping station. Hudson, N. H., has an 8-in. supply line from Tarnic Pond, and the writer's firm is this season constructing two water systems with wood pipe supply line, one with a four-mile distribution line in a suburban street. The smaller system is at Troy, N. H. The source of supply is a small stream that has its source in the west slope of Mt. Monadnock, and this wood supply line, some four miles in length, is of 12-in. and 10-in. pipe, the head is 310 ft., the distribution system is to be cast-iron pipe. This is now in progress of construction and is about three fourths completed. The wood pipe used is of the Michigan pattern.

The Pembroke water system is a reconstruction and extension of the former Suncock Water Works with a new source of supply. The old system, formerly owned by the Suncock Water Works Company that supplied water to Suncock Village in the town of Pembroke and Allenstown, was never satisfactory, either in the fire service rendered or the quantity or quality of the water furnished, and was acquired in 1914 by the town of Pembroke. In order to secure a satisfactory source it was found necessary to go to Pleasant Lake, fourteen miles distant, in the town of Deerfield, N. H. Lake Pleasant is 316 ft. above the lower level of Suncook Village. The first proposition was to convey the water from the lake to a reservoir nearer the village at a sufficient elevation for a good fire service, but as the pipe line, necessarily following the valley of the Suncook River, would pass through a populous section, including three villages in the town of Epsom, it was decided to draw direct from the lake and supplement the system with the old reservoir of the Suncook system, that had a capacity of three million gallons, for emergencies. This reservoir was not sufficiently high to cover the proposed extension to Pembroke Street, a residential section of the town north of the village. The supply pipe line, 14 miles in length, that is now nearly completed, is laid with 16-in., 14-in., and 12-in. wood stave pipe, and the suburban distribution line in Pembroke Street, four miles in extent, with 8-in. and 6-in. wood pipe. One half this pipe was purchased from the Wyckoff Company, of Elmira, N. Y., and the other half from the Michigan Pipe Company of Bay City, Mich. The saving in first cost under what it would have cost to construct these

lines with Standard cast-iron pipe is slightly over $52 000. One river crossing 110 ft. in length was made with cast-iron pipe. A section where the wood pipe saved considerable expense and difficulty was in the first two miles from the source. Here the pipe was laid through a swampy tract of land; a portion of it was an impassable morass except when the surface is frozen. This two miles was laid in December and January last. The surface at that time was frozen to a sufficient depth to allow teams to pass over it and provide a footing for the pipe layers. At places the flow of ground water was so copious that it required the continual use of a 6-in. Cameron steam pump operating day and night to care for it. The trench required close sheet, piling thoroughly braced. This was laid with 16-in. pipe, and it would have been almost an impossibility to have laid and calked cast-iron pipe in this section. As the lake is elsewhere surrounded by high hills and ridges, this was the only practical place to take a pipe line out of it. This pipe line was laid to a true grade. The bottom of the trench, which averaged about 10 ft. in depth, when the grade did not carry it through the mud or quicksand, was filled with brush and small wood removed from the right of way, the pipe was laid on this and weighted with sand bags, as it could not safely be filled with water until connected with the intake. Considerable difficulty was experienced by the clogging of the pumps first installed with vegetable matter and roots, but after securing the Cameron pump we had no further trouble of this kind. This supply line has been well equipped with both air and vacuum valves.

For the Pembroke Street installation, wood pipe was chosen, mainly for the reason that the Manchester and Concord Electric Railway passes over almost its entire length, and as no provision for a return current is made there, an iron pipe line would undoubtedly have formed this circuit, with the danger of electrolysis imminent. Upon Pembroke Street is located the Pembroke Academy, the Town Hall, several churches, and the best residences in the town. These, however, all have large lots and some extensive grounds so that the services are not very near together.

Ablett & Bowes, of Cohoes, N. Y., are the contractors for this work, and the difficult part of it, consisting of laying the 16-in. pipe through the bog, was done on the percentage plan, and a considerable saving was made in this way.

PLATE XIII.
N. E. W. W. ASSOCIATION.
VOL. XXX.
DUDLEY ON
EXPERIENCE WITH WOOD PIPE.

PEMBROKE WATER WORKS.
LAYING 16-IN. PIPE NEAR INTAKE.

PEMBROKE WATER WORKS.
SETTING GATE VALVE IN 14-IN. WOOD PIPE.

Mr. Frank S. Ablett, of the contracting firm, has been in immediate charge of the work, with Mr. Harry W. Sawyer, the business partner of the writer, as engineer in charge, and much credit should be given both for their constant and unremitting perseverance in pushing it through in the winter months, under constantly recurring difficulties.

The intake at the lake, which extends about 200 ft. into the water, and the gatehouse at its extremity, were completed in January, the ice forming a firm footing and support for the cofferdam used, and making access and delivery of material comparatively easy. Hot water was used in mixing mortar, and a stove inside the gatehouse helped in drying out and preventing freezing. This intake is in about fifteen feet of water, but as the lake at the time of its construction was drawn down to its low water limit, less than one half that depth had to be dammed.

The saving in wood pipe 8 in. and under is not nearly as much as on the larger pipes, and for city or village streets when services are taken off with close frequency should not be recommended.

To sum up the situation, wood pipe has, besides the saving in cost of both pipe and installation, these advantages:

1. It is preserved by water, and not rusted or corroded by it.

2. It is not corroded by any substance, or destroyed by acids or salts.

3. Its carrying capacity is 20 per cent. greater than cast-iron pipe, and remains constant, while that of metal pipe decreases with age.

4. It does not taint or affect fluids going through it.

5. It does not burst if frozen, the elasticity of the wood preventing it.

6. It requires less labor and experience to lay in place than metal pipe, and a considerable saving can be made here.

7. It can, when service pipes are not taken off, be laid in shallower ditches than metal pipe, for it is not so easily affected by frost.

8. In the writer's experience, while more or less joints show slight leakage when the pipe is first filled, they soon swell up and give less trouble in the end than cast-iron pipe.

THE PROPOSED AUXILIARY WATER SUPPLY OF BROCKTON, MASS.

BY ROBERT SPURR WESTON.*

[*Read March 8, 1916.*]

In the annual report of the Water Commissioners of the City of Brockton, Massachusetts, it was stated that, "during the hot, dry season, for several hours a day, and for a number of days, the consumption of water exceeded the capacity of the present main from Silver Lake. This indicates the need of a second main, more storage, or the use of the old supply at times."

The commissioners consulted their chemist and bacteriologist, Mr. George E. Bolling, who reported that by treatment of the water of the older source, namely, the Salisbury Brook Reservoir, with sulphate of alumina, followed by filtration through sand, the color of the water could be reduced to less than that of Silver Lake, the newer source, and used to supplement the present supply when necessary. At the further suggestion of Mr. Bolling, the writer was appointed to report on the general subject of auxiliary water supply, including an outline design of a purification plant should the same be found necessary.

In order to decide whether a second main, more storage, or the utilization of the older supply at times would be advisable, the writer studied with care the various reports of the water commissioners, of the Massachusetts State Board of Health, of Engineers Snow, Felton and FitzGerald, of Superintendent Kingman, and of Chemist Bolling. In addition, the existing sources of supply were examined with Mr. Horace Kingman, chairman of the board. The results of these studies are as follows.

Present Sources of Supply.

The water supply of Brockton dates from 1880, and was drawn first from the Salisbury Brook Reservoir in Avon. This source is

* Of Weston & Sampson, Consulting Engineers, 14 Beacon Street, Boston.

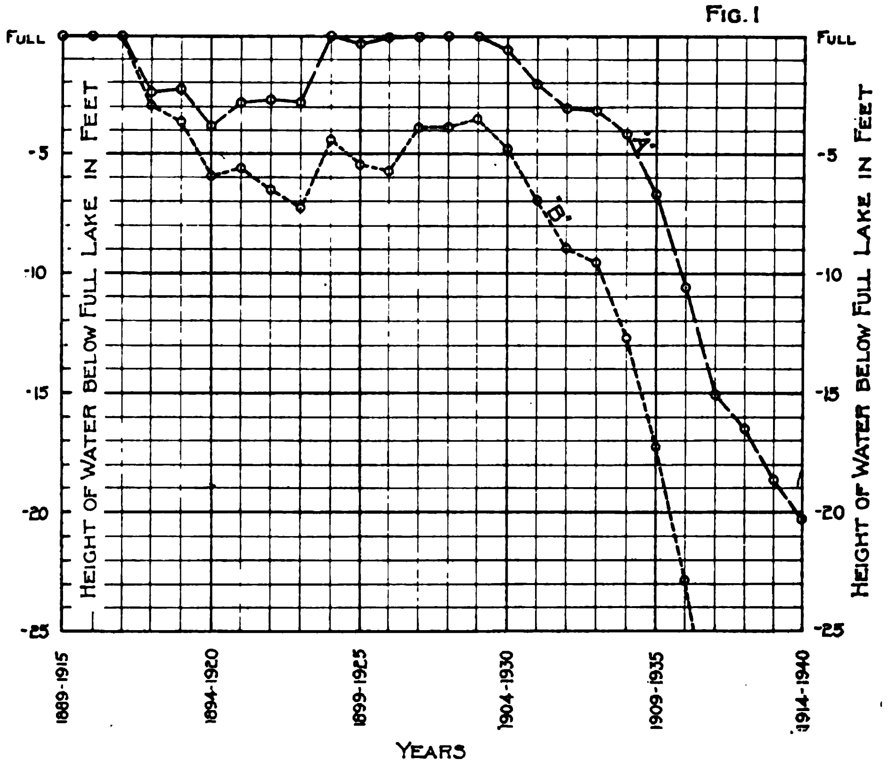
safe from a sanitary standpoint, but, on account of the high color, and vegetable odor and taste of the water, was never an entirely satisfactory supply from the consumer's standpoint. In 1904, the increasing consumption of the growing city exceeded the yield of this reservoir, and on October 12 of the same year the new Silver Lake supply was put into service. This excellent source has now served the city for eleven years, and has a safe yield of 3 500 000 gal. without drawing down the lake materially.

As a source of supply, Silver Lake leaves little to be desired. The water is soft, clear, of low color, and almost free from objectionable odors and tastes. Furthermore, the drainage area is sparsely inhabited, and the reports of the city chemist show the water to be suitable for all purposes. It is delivered by means of two pumps, each having a capacity of 6 000 000 gal. daily, through a 24-in. pipe line 11.62 miles long, discharging into two distributing reservoirs located in Avon and having a total capacity of 8 000 000 gal. The capacity of the pipe line is now 6 000 000 gal. daily.

Yield of Silver Lake.

In 1897, Messrs. Snow and Kingman reported on the Silver Lake supply, as did Messrs. Felton and FitzGerald in 1901. The lake, when full, has an area of 644 acres (*about one square mile*) and a storage capacity of 5 371 000 000 gal. below high-water mark. Mr. Felton estimated that Silver Lake would supply 3 500 000 gal. daily without drawing down the level of the water more than 11 ft. He also estimated that 4 000 000 gal. daily might be obtained by drawing the lake down 20 ft.

Mr. Felton's studies were based on the rainfall records and the Sudbury River run-off records for twenty-five years ending with 1899. Similar studies by us, using the same method, but based on the rainfall and Sudbury records for the twenty-five years ending with 1914, are given in Fig. I. This shows that a draft of 3 500 000 gal. a day would draw Silver Lake down 16 ft. by 1938, while a draft of 4 000 000 gal. would draw it down 16 ft. by 1935. The difference in these two estimates in result is explained by the lower rainfall for the period 1889–1913 than for the period 1875–1899, taken by Mr. Felton.



Brockton Water Works,
Brockton, Mass.

Height of Water in Silver Lake 1915-1940
Assuming Yearly Yields similar to Period 1889-1914

A - Average Draft, 3,500,000 Gallons per Day
B - Average Draft, 4,000,000 Gallons per Day

The following data from the Sudbury River records show the difference between the periods:

DATA FROM SUDBURY RIVER RECORDS.

Average rainfall, 1875–1899	45.83 in.
Average rainfall, 1889–1913	44.99 in.
Average rainfall, 1875–1913	44.99 in.
Average yield, 1875–1899	1 069 720 gals. per day per sq. mile.
Average yield, 1889–1913	976 840 gals. per day per sq. mile.
Average yield, 1875–1913	1 000 000 gals. per day per sq. mile.

It will be noted that the average rainfall for the period 1889–1913 happens to be the same as for the whole period 1875–1913, while that in the period 1875–1899 is 0.84 in. higher.

The average yield of the land surface of the Sudbury River drainage area for 1875–1913 was 1 000 000 gal. per square mile; and on the same basis the 3.4 square miles of drainage area of Silver Lake would yield 3 400 000 gal. per day without drawing upon the storage within the lake. While the rainfall at Silver Lake probably averages slightly less than at Sudbury, the drawn down lake would yield slightly more because of the sandy character of the soil. Therefore it may be stated definitely, as a result of various estimates and experience, that Silver Lake may be depended upon to furnish 3 500 000 gal. without depressing the surface of the lake more than 11 ft.; and 3 830 000 gal. daily without drawing it down more than 16 ft. These seem eminently safe estimates.

EFFECT OF REDUCTION OF STORAGE ON THE QUALITY OF WATER.

The depth 16 ft. has been assumed as the point below which Silver Lake might not be drafted. This is the depth assumed by Mr. Felton, and, with the lake so drawn down, the storage capacity would be reduced one half, as the following table (Felton, 1901 Report, p. 40) shows.

The present excellent quality of Silver Lake is due to the very long storage of the water which enters it. For example, the average colors of the water of Tubbs Meadow Brook and Jones River, the main feeders of Silver Lake, are 1.00 and 1.96, respectively. These colors are reduced to 0.09 by long storage before the water

STORAGE CAPACITY OF SILVER LAKE.

Depth.	Area. Acres.	Storage Capacity. Gallons.
At high water,	644	5 371 361 000
5 feet below high water,	538	4 370 334 000
10 " "	414	3 562 659 000
15 " "	372	2 902 487 000
20 " "	337	2 312 314 000
25 " "	286	1 801 163 000
30 " "	238	1 352 906 000
40 " "	120	606 471 000
50 " "	64	198 215 000
60 " "	21	37 305 000
70 " "	2	

is used. It is obvious, therefore, that any considerable reduction in storage, like 50 per cent., will impair the quality of the water more or less. Furthermore, the writer believes that such a reduction in storage might cause increases in the growths of those organisms which produce objectionable odors and tastes in the water. Some of these organisms, for example, Anabæna, have appeared in Silver Lake from time to time in large enough numbers to be noticed, also numbers of less objectionable organisms like Melosira. The following table, compiled from Mr. Bolling's reports, shows the frequency of occurrence of organisms in the past.

OCCURRENCE OF MICROSCOPICAL ORGANISMS IN SILVER LAKE WATER, 1906–1914.

Year.	No. of Examinations.	No. of Organisms per C.C.		Variations in Organisms per C.C. No. of Counts.				
		Mean.	Median.	Less than 100.	100 to 500.	500 to 1 000.	1 000 to 2 000.	Above 2 000.
1906	45	466	226	5	33	4	2	1
1907	58	222	199	2	34	12	4	6
1908	47	333	274	7	20	8	2	10
1909	41	604	362	4	19	7	6	5
1910	41	431	336	5	25	11	1	0
1911	48	677	358	1	29	13	4	1
1912	47	899	279	5	30	12	0	0
1913	44	866	358	9	25	10	0	0
1914	48	437	185	9	22	10	7	0
Average	47	548	286	5	26	10	3	3

Because about 10 per cent. of the tests show the presence of more than 1 000 organisms per c.c., and objectionable organisms in numbers large enough to be noticeable have been found during the years 1905, 1906, 1907, 1908, 1910, 1911, and 1914, it is not safe to assume that the storage could be reduced one half without at the same time introducing conditions more favorable to growths of objectionable organisms.

Because it requires long storage to reduce the color of the water entering the lake, it seems reasonable that the removal of color would not be so great were the storage reduced one half.

To preserve the excellent character of the water, the lake should be kept as full as practicable. If, in the future, Howard and Pine brooks be diverted to Silver Lake, thereby increasing the supply by 3 390 000 gal. daily, it may be best at the same time to maintain the longer period of storage by increasing the height of the dam at the outlet. Although Silver Lake has a safe yield of 3 500-000 gal. daily, or a higher yield if the storage be drawn upon, it must be supplemented in the not very distant future by other sources. The time when this increase should be made is estimated as follows.

Population.

Until recently, Brockton has grown very rapidly. In 1901 it was estimated by former City Engineer Charles R. Felton that in 1915 the population would be nearly 67 300. Owing to industrial conditions, however, the rate of growth has declined, and the state census for 1915 gives Brockton a population of but 61 944. It is believed, however, that this decline in the rate of increase is not permanent, and the rate of increase will be greater in the future than it has been recently.

Since January 1, 1905, the town of Whitman has been supplied from Silver Lake. The present population of this town is 7 443. At present, water is also furnished to West Bridgwater (population 2 736), to a portion of Hanson (population 600), and to a portion of East Bridgewater (population 210). In addition, connections are now being made to supply a portion of Easton (population 1 000) from the same source.

The future population of Brockton has been estimated by several

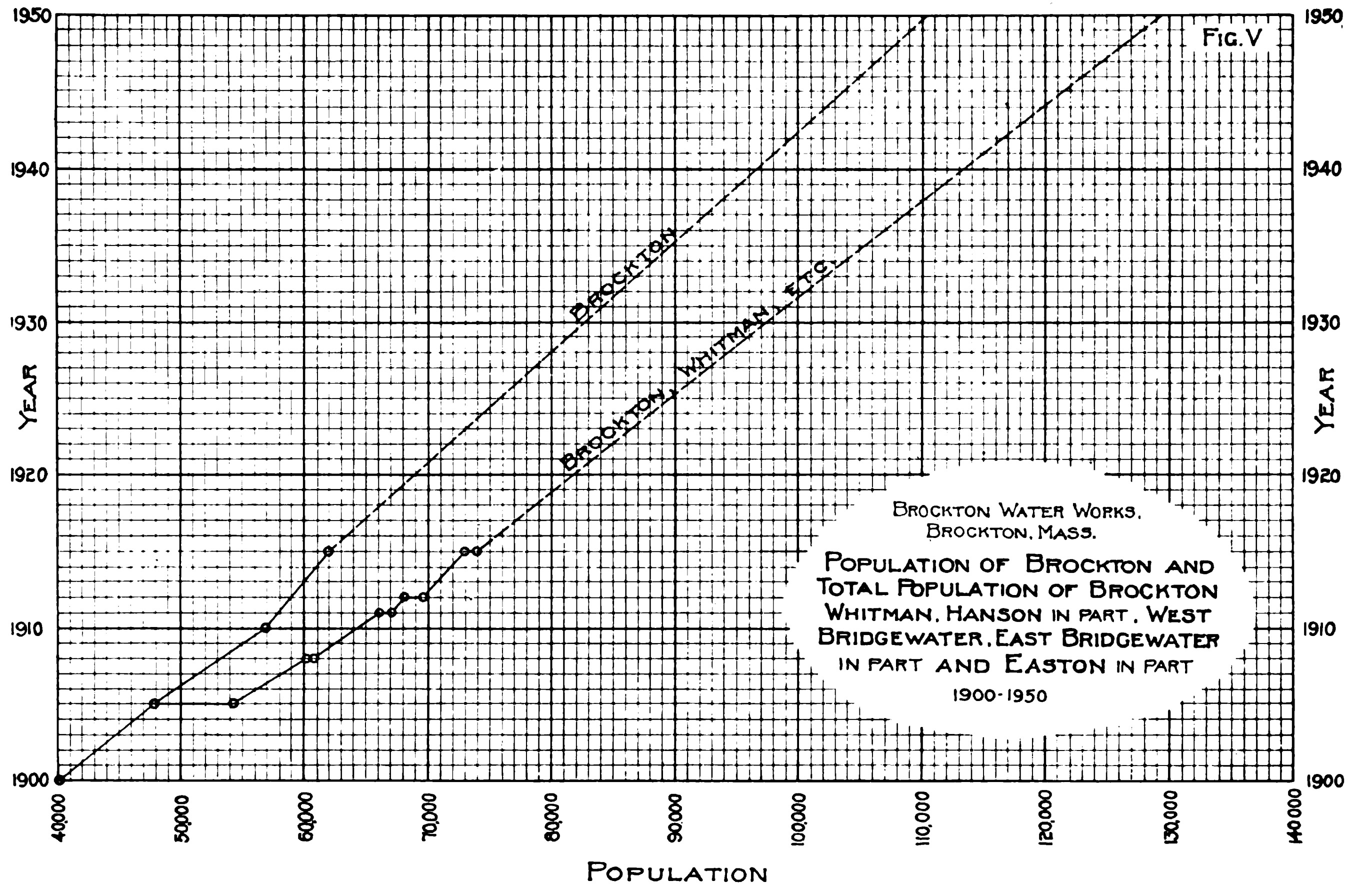


FIG. V
BROCKTON WATER WORKS.
BROCKTON, MASS.
POPULATION OF BROCKTON AND TOTAL POPULATION OF BROCKTON WHITMAN, HANSON IN PART, WEST BRIDGEWATER, EAST BRIDGEWATER IN PART AND EASTON IN PART
1900-1950
BROCKTON
BROCKTON, WHITMAN, ETC.
YEAR
1900
1910
1920
1930
1940
1950
POPULATION
40,000
50,000
60,000
70,000
80,000
90,000
100,000
110,000
120,000
130,000
140,000

engineers in the past. Their estimates have been examined, revised to conform with the census records which have been made since, and on this basis new estimates have been made, — not only of Brockton but of all the neighboring communities supplied from the Silver Lake source. These populations are given in the following table and are plotted in part on Fig. V.

Consumption of Water.

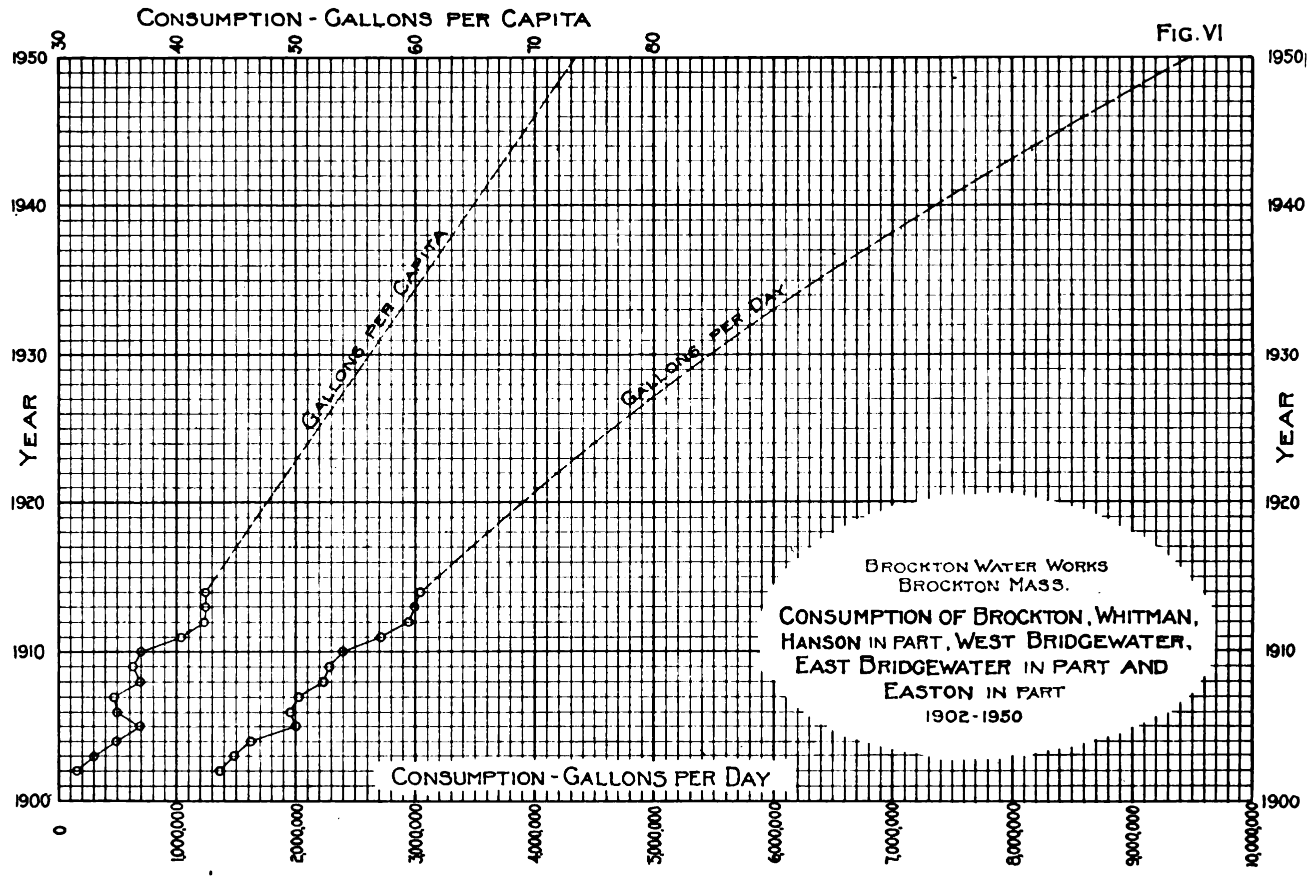
The following table shows the consumption of water in Brockton since 1900, and in Brockton, Hanson, East and West Bridgewater since 1905. It also shows the estimated consumption for the part of Easton, connections with which have just been made. The consumptions are estimated until 1950. Both the total and the per capita consumptions are given in the table, and are plotted on Fig. VI.

Year.	Population.	Consumption.	
		Gallons per Capita per Day.	Total Average Daily.
1900	46 218	29.3	1 354 000
1905	54 315	36.9	2 006 000
1910	64 170	37.0	2 374 000
1915	73 930	43.3	3 201 000
1920	81 720	47.6	3 890 000
1925	89 530	51.9	4 647 000
1930	97 420	56.2	5 475 000
1935	105 360	60.4	6 364 000
1940	113 400	64.8	7 348 000
1945	121 450	69.1	8 392 000
1950	129 450	73.3	9 489 000

Time of Increase in Silver Lake Supply.

Mr. Felton estimated that the consumption of Brockton and Whitman would reach the safe yield of Silver Lake in 1918, and that, by drawing the water down 16 ft., it might be used without addition until about 1930. Since Mr. Felton's estimate was made, West Bridgewater, East Bridgewater, Hanson, and part of Easton have been added to the district supplied. Furthermore, the per

FIG. VI



CONSUMPTION - GALLONS PER CAPITA
30
40
50
60
70
80
1950
1940
1930
1920
1910
1900
YEAR
GALLONS PER CAPITA
GALLONS PER DAY
BROCKTON WATER WORKS
BROCKTON MASS.
CONSUMPTION OF BROCKTON, WHITMAN, HANSON IN PART, WEST BRIDGEWATER, EAST BRIDGEWATER IN PART AND EASTON IN PART
1902-1950
CONSUMPTION - GALLONS PER DAY
0
1,000,000
2,000,000
3,000,000
4,000,000
5,000,000
6,000,000
7,000,000
8,000,000
9,000,000
10,000,000

capita consumption has exceeded the estimate, as shown by the tables and diagrams accompanying this report. On the other hand, the estimates of future population for Brockton and especially Whitman, made by Mr. Felton, were considerably more than we are able to make at the present time, so that the differences nearly balance one another. They are compared in the following table.

TABLE SHOWING ESTIMATED WATER CONSUMPTION OF THE BROCKTON WATER DISTRICT.

Year.	Per Capita Consumption. Gallons per Day.		Total Consumption. Gallons per Day.	
	Felton's Estimate. (1901.)	Present Estimate. (1915.)	Felton's Estimate. (1901.)	Present Estimate. (1915.)
1915	39	43	3 042 000	3 201 000
1920	41	48	3 788 400	3 890 000
1925	43	52	4 635 400	4 647 000
1930	45	56	5 625 000	5 475 000
1935		60		6 364 000
1940		65		7 348 000
1945		69		8 392 000
1950		73		9 489 000

It is obvious that the draft from Silver Lake will exceed the average yield of the drainage area by 1918, just as estimated by Mr. Felton, and that by drawing from storage the lake may possibly be used until the dates given in the following table.

TABLE SHOWING TIMES WHEN ESTIMATED WATER CONSUMPTION WOULD EQUAL THE YIELD OF SILVER LAKE, PLUS THE STORAGE, WHEN DRAWN TO VARIOUS DEPTHS BELOW HIGH WATER.

(Based on Average Yield of Silver Lake.)

Year.	Consumption. Gallons per Day.	Depression of Water Level. Feet.
1919	3 743 000	1
1922	4 183 000	5
1925	4 647 000	10
1927	4 968 000	15
1928	5 137 000	20

In the light of the above evidence, it would seem wise to supplement Silver Lake not later than 1927, in order to meet the average consumption — perhaps earlier if increased draft causes the quality to deteriorate.

Relation of Maximum Consumption to Average Consumption.

While Silver Lake alone might supply the average amount of water required until 1927, the maximum daily amount must be furnished also. During the past year, the maximum daily consumption has at times exceeded 6 000 000 gal. daily, or more than the designed capacity of the pipe line from Silver Lake. To pump 6 000 000 gal. in twenty-four hours through the present 24-in. pipe line means pumping against a friction head of 102 ft. As the pipe gets older, the friction head will increase, as estimated in the following table.

Table showing Increase in Friction Head in the 24-inch Silver Lake Pipe Line, Due to Age.

(Based on Hazen and Williams Hydraulic Tables.)

Year.	Friction Head in Feet at Pumping Rate of 6 000 000 Gal. Daily.	Volume of Water which may be Pumped Daily without increasing the Present Friction Head above 102 Ft.
1904	74.9	6 805 000
1910	89.6	6 355 000
1915	101.9	6 000 000
1920	113.6	5 660 000
1925	126.5	5 340 000
1930	140.0	5 055 000
1935	153.5	4 800 000
1940	166.0	4 575 000
1945	180.8	4 390 000
1950	194.4	4 235 000

Not only has the maximum daily consumption reached the capacity of the Silver Lake pipe line, but during the summer of 1914 there were times during certain days when the district was using water faster than it was pumped from Silver Lake. This was possible by drawing from the two concrete distributing reservoirs in Avon. These have a capacity of only 8 000 000 gal., and should

the period of maximum consumption be greatly prolonged, or a severe fire occur during this period, a shortage of Silver Lake water would be liable to occur. The possibility of this shortage was foreseen by Mr. Felton in 1901, and he believed that when it occurred the present Salisbury Brook Reservoir would serve as an auxiliary, although he states that " it is a grave question whether public opinion would sanction the use of a poorer water, still it seems only fair that those sources should be considered as an auxiliary to Silver Lake. . . . At this time, if it were deemed advisable, it might be used in connection with filtration."

Quality of Salisbury Brook Reservoir Water.

During the past few years, when attempts have been made to use water from the Salisbury Brook Reservoir as an auxiliary source of supply, serious complaints have arisen on account of the color of the water, which averages 0.52, while the color of the Silver Lake water is only 0.09. This means that on many streets, particularly in the northern part of Brockton, the water in a certain house might be alternately high and low colored, — that is, alternately disagreeable and agreeable.

The color of the water has varied since 1887, as shown by the analyses of the Massachusetts State Board of Health, which are tabulated on the following page.

When the reservoir was constructed, neither the vegetation nor the soil were removed by stripping, and during the first years the color of the water was very much higher than subsequently, the average color for the first five-year period being 0.78, for the last five-year period 0.51. In 1889 the color of the water reached 1.30, but during the last five years the maximum was 0.84, and during the same period the minimum color was 0.23, as low as it has ever been. Generally speaking, the water has improved with time.

As recommended by Mr. Felton in 1901, the Salisbury Brook Reservoir has been maintained as a possible future auxiliary source. The reservoir has been kept in good condition, and careful supervision has protected the water against pollution. It is, therefore, safe to use, but it is absolutely necessary, in order to make this supply available as an auxiliary, that it be decolorized. Were its disagreeable characteristics removed by purification, it would be

COLOR OF WATER FROM SALISBURY BROOK RESERVOIR.
1887–1914.

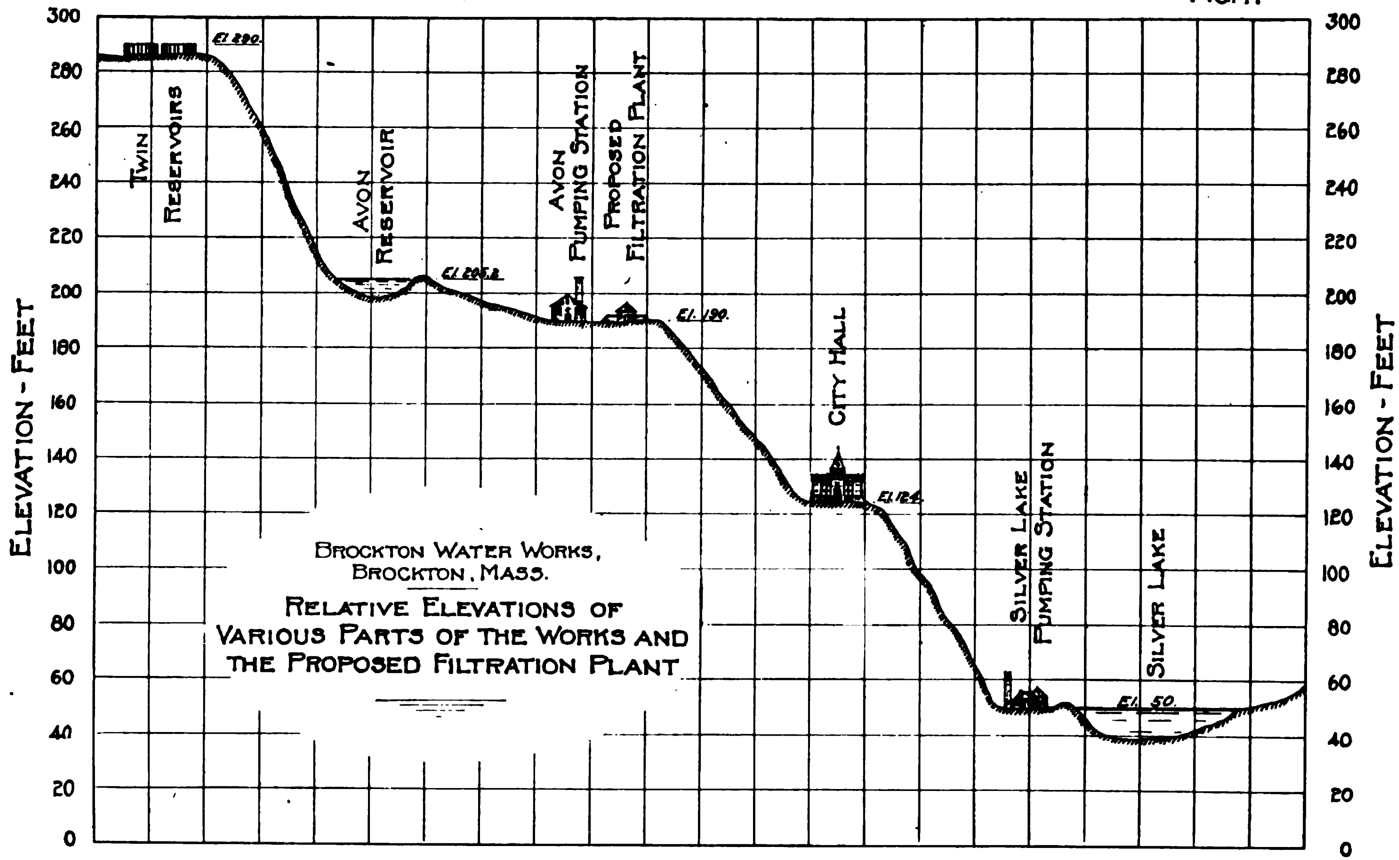
Year.	Color of Water.		
	Annual Average.	Maximum.	Minimum.
1887	.98	1.2	.8
1888	.76	1.1	.45
1889	.78	1.3	.4
1890	.75	1.0	.45
1891	.62	.90	.40
1892	.55	.80	.30
1893	.67	.90	.60
1894	.81	.95	.68
1895	.80	1.10	.52
1896	.64	1.00	.40
1897	.85	1.03	.60
1898	.73	.98	.50
1899	.48	.77	.32
1900	.57	.75	.36
1901	.62	.96	.46
1902	.49	.65	.27
1903	.51	.63	.33
1904	.55		
1905	.50	.71	.37
1906	.54	.70	.37
1907	.51	.66	.36
1908	.46	.75	.23
1909	.54	.70	.34
1910	.49	.76	.25
1911	.41	.60	.23
1912	.64	.84	.35
1913	.51	.75	.30
1914	.51	.65	.25

practically as agreeable a supply as Silver Lake, besides being an available auxiliary to supply the city during conflagrations, or during other periods of abnormal consumption, or should a break in the Silver Lake pipe line occur. It would postpone the time when it would be necessary to add to the Silver Lake supply.

YIELD OF SALISBURY RESERVOIR.

The old reservoir in Avon has an area of approximately 92 acres with the flashboards in place on the dam, and the catchment area supplying the reservoir is 3.11 square miles. The average total yield of the Salisbury Brook source is 3 110 000 gal. daily, or about

Fig. 11


Brockton Water Works,
Brockton, Mass.
Relative Elevations of
Various Parts of the Works and
the Proposed Filtration Plant
Elevation - Feet
Twin Reservoirs
El. 290.
Avon Reservoir
El. 205.2
Avon Pumping Station
Proposed Filtration Plant
El. 190.
City Hall
El. 124.
Silver Lake Pumping Station
Silver Lake
El. 50.
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0

92 per cent. of that of the Silver Lake catchment area, but the storage in the reservoir is only 309 291 000 gal. at high-water mark, as compared with 5 371 361 000 gal. in Silver Lake. Because of the smaller storage, this supply cannot be depended upon to furnish more than 1 500 000 gal. daily in a dry year.

The value to Brockton of the old reservoir as an auxiliary is far beyond what it will yield safely in a dry year. Much larger volumes than 1 500 000 gal. daily may be drawn from this reservoir in an emergency. If this source were used, it would seem best to provide a purification plant having a capacity equal to the capacity of the present pump, — namely, 5 000 000 gal. daily. The old reservoir, when full, would furnish 5 000 000 gal. daily for a period of thirty-eight days beginning in the driest month of the driest year, or one hundred nine days on the average, and this without drawing down the reservoir more than eight feet.

The Salisbury Brook Reservoir has other practical advantages as an auxiliary, in that it is 155 ft. higher than Silver Lake and eleven miles nearer City Hall.

The relative elevations of the various parts of the works and the proposed filters are shown on Fig. II.

Best Method of Color Removal.

The usual method of color removal is to treat the water with sulphate of alumina, which immediately reacts with the water and, after storage for from one to three hours, forms a precipitate with which a large part of the color combines. The degree of color removal is controlled by varying the dosage of applied chemical. The alumina added with the chemical is completely removed by subsequent filtration, either through slow or rapid sand filters; the sulphate added displaces an equivalent amount of carbonate with the formation of carbon dioxide, a harmless gas which remains in the water.

Slow filters in this case could be operated at the rate of 6 000 000 gal. per acre per day, and to decolorize 5 000 000 gal. would require one acre of filter surface. In addition, there would have to be a large coagulating basin in order to remove by precipitation the major part of the precipitated sulphate of alumina and color, which otherwise would clog the slow filter too rapidly. The modified

slow filter plant as just outlined would cost over $135 000, exclusive of the additional land which would be required.

The treated water could be filtered through rapid filters at a rate of 125 000 000 gal. per acre per day, after passing through a coagulating basin holding the equivalent of two or three hours' flow. Less chemical would be required than with slow filters. This plant could be located for the most part on the existing pumping station lot, as shown by the sketches accompanying this report.

Considerations which Govern the Choice of Method.

The slow filter, without chemicals, is best adapted to the purification of slightly turbid and slightly colored waters which are subject to sewage pollution. A slow filter is easier to operate than a rapid filter. On the other hand, slow filters are not suited to the decolorization of water or the purification of waters containing large amounts of suspended matter, unless the water be first treated with chemicals, followed by subsidence. Slow filters to treat colored waters were installed at Philadelphia (Torresdale), Albany, and Springfield, and in the beginning operated without the aid of chemicals, but it has since been found necessary in these cities to pre-treat the raw water with chemicals in order to obtain satisfactory results.

Rapid filters are best adapted to the purification of waters containing a color of more than 0.20 or a turbidity of more than three parts per 100 000. On the other hand, they must be operated carefully in order to secure the best results. One of the difficulties in operation is to properly dose a water which changes its character rapidly, making necessary rapid changes in the dose of chemicals. Waters which are drawn from reservoirs, however, are not apt to change rapidly in character.

Inadequacy of Purification without the Addition of Chemicals.

The use of a slow filter without coagulants, even at a rate as slow as 3 000 000 gal. per acre per day, would effect the removal of only about 40 per cent. of the coloring matter. That is, the present average color of the Salisbury Brook Reservoir water, 0.52, would

be reduced to an average of 0.31, or about three times that of Silver Lake. At times of high color the filtered water color would exceed 0.50. It would be folly to go to the greater expense of slow filters ($100 000 as compared with $70 000) and then produce a filtered water three times as highly colored as Silver Lake. It would mean that on certain streets the water would vary in color from hour to

TABLE SHOWING AMOUNTS OF COLOR REMOVED BY DIFFERENT METHODS OF WATER PURIFICATION.

By Slow Filters, without Preliminary Treatment.

City.	Year.	Color.						Authority.
		Raw Water.			Filtered Water.			
		An. Av.	Max.	Min.	An. Av.	Max.	Min.	
Lawrence, Mass....	1913	.33			.18			M. S. B. of H.
Athol, Mass........	1913–14	.84	2.20	.30	.50	1.15	.18	J. L. Tighe
Providence, R. I....	1912	.49	.67	.35	.29	.42	.20	R. I. S. B. of H.
Pittsburg, Pa.......	1912	.047	.07	.03	.03	.05	.02	An. rep., City P.
Hudson, N. Y......	1910–11	.17	.30	.10	.08	.15	Trace	N. Y. S. B. of H.
Poughkeepsie, N. Y.	1911	.31	.40	.25	.24	.30	.20	N. Y. S. B. of H.
Yonkers, N. Y......	1911	.12	.15	.10	.05	.10	Trace	N. Y. S. B. of H.

By Slow Filters, with Preliminary Treatment.

City.	Year.	Raw An. Av.	Raw Max.	Raw Min.	Filtered An. Av.	Filtered Max.	Filtered Min.	Authority.
So. Norwalk, Conn.	1909	.29	.60	.19	.09	.15	.05	C. S. B. of H.
Torresdale, Philadelphia, Pa.	1914	.15	.19	.12	.10	.12	.08	F. D. West

By Rapid Filters, with Chemical Treatment.

City.	Year.	Raw An. Av.	Raw Max.	Raw Min.	Filtered An. Av.	Filtered Max.	Filtered Min.	Authority.
Elmira, N. Y.......	1913	.15	.30	.08	.01	.05	Trace	N. Y. S. B. of H.
Cohoes, N. Y.......	1913	.22	.33	.12	.08	.12	Trace	N. Y. S. B. of H.
Rensselaer, N. Y....	1913	.26	.40	.15	.02	.05	Trace	N. Y. S. B. of H.
Binghamton, N. Y..	1911	.11	.15	Trace	.03	.10	Trace	N. Y. S. B. of H.
Little Falls, N. J....	1912	.46	.92		.08	.22		F. W. Greene
Minneapolis, Minn..	1914	.49			.18			Plant record
Wilkinsburg, Pa....	1914	.28			.00			J. M. Caird
Exeter, N. H.......	1913	.30	.85	.10	.06	.25	.02	R. S. W.
Biddeford, Me......	1915	.11	.33	.02	.04	.20	.00	R. S. W.
Arlington Mills, Lawrence, Mass..	1915	1.31	1.75	.80	.16	.20	.10	R. S. W.
E. Greenwich, R. I..	1912	.43	.78	.18	.04	.10	.02	R. I. S. B. of H.
E. Providence, R. I.	1912	.60	1.50	.30	.06	.13	.02	R. I. S. B. of H.

hour and from day to day, as the supply would be drawn from Silver Lake or the Salisbury Brook Reservoir. This would not suit the consumers. By the use of chemicals, however, the color can be reduced to less than 0.10, less than the color of Silver Lake water.

In confirmation of this opinion, the writer would offer the preceding table, showing the average, maximum, and minimum colors of the raw and filtered water supplied to several cities. This table shows that single slow filters without chemical treatment remove on the average 40 per cent. of the color, that double filtration without coagulating chemicals removes 57 per cent., whereas 82 per cent. of the color is removed by rapid filters with chemical treatment.

Single, slow filters which remove the larger percentages of color without chemicals usually operate with river waters or those having the coloring matter in a semi-suspended state. With the comparatively clear reservoir or settled waters they are least efficient.

Effect of Chemical Treatment on Hardness.

Salisbury Reservoir water would require the addition of about thirty parts of sulphate of alumina per million in order to decolorize it. To absolutely prevent any increase in the hardness, and to make sure that no undecomposed chemical passes the filter, there must be present in the water alkali enough to completely precipitate the chemical. The natural alkalinity of the water is hardly sufficient, and therefore it will be necessary to add to the water about eight parts of alkali, in the form of soda, per million, before the addition of the sulphate of alumina. At Exeter, N. H., no alkali is added, yet the hardness increases very slightly (from 2.73 to 3.03 parts per 100 000). This slight increase in hardness may be avoided by the addition of alkali.

Best Filter for Brockton.

The writer holds no brief for one filter or the other, but, to decolorize the Salisbury Brook water, chemicals must be used, and chemicals can be used most economically and efficiently with a rapid filter, properly designed, constructed, and operated.

Distributing Reservoirs.

Distributing reservoirs are necessary for meeting emergencies, and, if large enough, may be used to overcome the discrepancies between average and maximum consumptions. The two Avon reservoirs will hold one day's maximum supply until the average consumption reaches 4 000 000 gal. daily. It is necessary that one day's supply be available at all times for emergencies, but to insure this the source must be able to supply water faster than it is used on days of largest consumption. If, for example, the maximum consumption exceeds the capacity of the pipe line for several days in succession, as it has and will, the reserve in the reservoirs will be gradually destroyed and the emergency which they are designed to meet (such as a break in the Silver Lake pipe line or a bad fire) may occur when they are drawn down too far to be of service.

The maximum consumption, also, might be met by the construction of reservoirs. Unfortunately no good natural sites for the construction of a large distributing reservoir at a sufficient elevation exist near Brockton. Consequently artificial reservoirs would have to be used. The two excellent concrete reservoirs which the city now owns are as economical as could be built, and cost $10 000 per million gallons capacity. Consequently the cost of storage to furnish a supply of 5 000 000 gal. daily for varying times would be the amounts shown in the following table.

Cost of Reservoirs for Furnishing 5 000 000 Gallons Daily for Various Periods.

Time.	Capacity. Gallons.	Cost.
1 day	5 000 000	$50 000
2 days	10 000 000	100 000
5 days	25 000 000	250 000

Reservoirs costing the same as an additional 24-in. main ($345-000) would store only seven days' supply, and those costing as little as a purification plant ($70 000) would store only one and one-half day's supply.

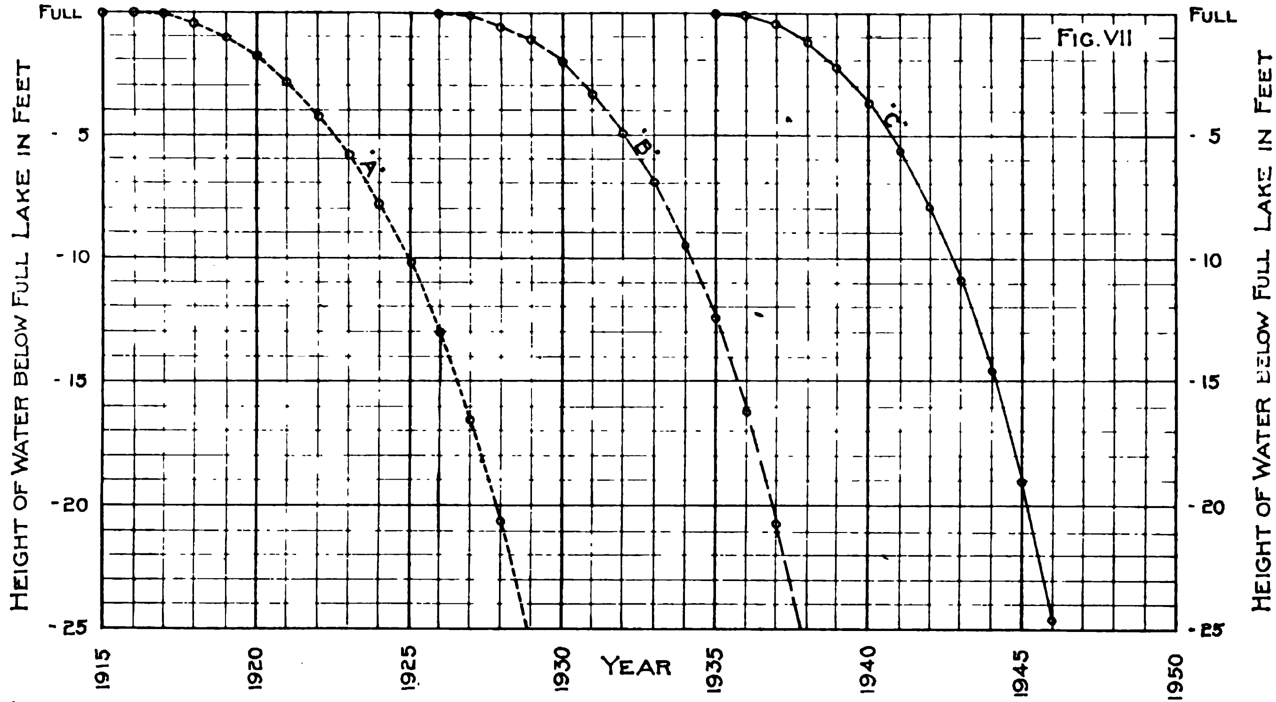
New distributing reservoirs of 4 000 000 gal. capacity ought to be added to the supply from time to time, to store the necessary one day's consumption at the maximum rate. If a new pipe line be installed, no new reservoir need be built until 1921. If the pipe line be postponed and Salisbury Brook water be purified, so that both sources of supply may be used when necessary, the construction of more distributing reservoirs may be postponed until a new pipe line larger than 24 in. in diameter is required.

Because of their very high unit cost, and because either of the other methods suggested meets the deficiencies of supply more liberally and efficiently for the same expenditure, and because the present reservoirs store enough water to meet the emergencies for which they were built, the construction of new reservoirs would be neither timely nor expedient.

Pipe Line *v.* Purification Plant.

A new pipe line to Silver Lake would give the necessary relief to the city until at least 1927, when the Silver Lake source should be supplemented in order to avoid drawing below 16 ft. The best way of doing this may be determined at that time. The present evidence is in favor of diverting the flow of Howard and Pine brooks, which would add 3 390 000 gal. daily to the quantity which might be drawn from Silver Lake. Further additions might be made from other ponds and streams in the vicinity of Silver Lake, as reported previously (Snow and Kingman, Report, 1897).

However, the present pipe line has a capacity of 6 000 000 gal. when the pumps are working against a friction head of 102 ft., while Silver Lake has an average yield of 3 500 000 gal. The capacity of the pipe line is, therefore, greatly in excess of the average yield of the lake. It therefore seems unwise, apart from financial considerations, to lay a new pipe line simply to serve as an auxiliary when the present main can deliver more than the average yield of the lake. If the line were laid, the pipe capacity would be more than doubled for the present, decreasing as the lines aged. The two mains would supply the city until 1931, when a third main, 30 in. in diameter, would be required. It would seem better, therefore, to postpone the construction of a 24-in. pipe line until



A - Silver Lake alone at an average yield of 1,000,000 gallons per day per square mile

B - Silver Lake at 1,000,000 gallons per day per square mile and Avon Reservoir at 1,500,000 gallons per day.

C - Silver Lake at 1,000,000 gallons per day per square mile and Avon Reservoir at 1,000,000 gallons per day per square mile.

Brockton Water Works
Brockton, Mass.

Height of Water in Silver Lake by Years with Consumptions as Estimated
1915-1950

Silver Lake has to be added to, when a larger pipe line (36-in.) should be laid, taking the place of the two smaller mains which the other plan would demand; and effecting a great saving in cost. Meanwhile, the deficiencies should be made up with purified Salisbury Brook Reservoir water.

It is obvious that if the construction of the inevitable additional pipe line be postponed, say until 1931, it would be practicable to lay a pipe as large as 36 in. in diameter, which, with the present 24-in. line and the Salisbury Brook filters, would supply the Brockton District to the probable capacity of both sources, increased by probable additions to Silver Lake. By adding other sources to Silver Lake, a new 24-in. pipe line would serve as an auxiliary until 1931. So would the old source if some of the "large amount of water now going to waste in the winter and spring" be used in addition to the dry weather yield of the reservoir, as recommended by Mr. Felton, to reinforce the Silver Lake supply, as shown on Fig. VII.

The future supply would be much more flexible if taken from two sources than from one alone. With the old supply available as an auxiliary, a break could occur in the Silver Lake line and the various quantities of water could be supplied from the old source for the times given in the following table.

QUANTITIES OF PURIFIED WATER WHICH COULD BE SUPPLIED FROM SALISBURY BROOK RESERVOIR AND PRESENT DISTRIBUTING RESERVOIRS, SHOULD AN ACCIDENT HAPPEN TO THE SILVER LAKE PUMPS OR PIPE LINE.

Gallons per Day.	Number of Days.
5 000 000	Not less than 38
6 000 000	8
7 000 000	4
8 000 000	2.7
9 000 000	2.0
10 000 000	1.6
11 000 000	1.3
12 000 000	1.1
13 000 000	1.0

The quantities in the above table would be ample until an additional pipe line to Silver Lake would be needed. Another advan-

tage of the Purification Plan is that Silver Lake would last at least four years longer and without using more than the dry weather yield of the old source.

Experience has shown that the hygienically safe Salisbury Brook water can be made attractive; furthermore, it is a convenient auxiliary and is also more economical than a new 24-in. pipe line.

A comparison of the two programs is given in the following table. In this table, it is assumed that Silver Lake may be drafted 16 ft. without injuring the quality of the water. Should this assumption prove incorrect, additions to Silver Lake would have to be made earlier than the dates given.

COMPARISON OF PROGRAMS NECESSITATED BY TWO METHODS OF AUXILIARY SUPPLY, ASSUMING SILVER LAKE TO BE DRAWN DOWN 16 FEET AND ONLY THE DRY WEATHER FLOW OF SALISBURY BROOK RESERVOIR UTILIZED.

Year.	24-In. Pipe Line Plan.	Purification Plan.
1916	24-in. pipe line, $345 000.	Purification plant, $70,000.
1917		
1918		
1919		
1920		
1921	New reservoir.	
1922		
1923		
1924		
1925		
1926		
1927	Additions to Silver Lake.	
1928		
1929		
1930	30-in. pipe line and pump.	36-in. pipe line and pump.
1931		Additions to Silver Lake.
1932		
1933		
1934		
1935		
1936		New reservoir.

FINANCIAL CONSIDERATIONS.

The first cost of a new 24-in. pipe line is estimated at $345 000; of a purification plant having a capacity of 5 000 000 gal. daily, at

$70 000. The interest and sinking fund charges during the life of the bonds, and beginning 1917, may be estimated as follows:

	24-In. Pipe Line.	Purification Plant.
Interest, 4 per cent.	$13 800	$2 800
Sinking fund payments, basis 3.75 per cent.	6 180	1 254
Total annual fixed charges	$19 980	$4 054

These estimates, capitalized at 4 per cent. interest for eleven years, — the end of the period during which it is estimated that Silver Lake will furnish enough water to supply the average consumption of the district, — will amount in 1927 to the following:

ACCUMULATED VALUE OF FIXED CHARGES, 1927.

	24-In. Pipe Line.	Purification Plant.
Value of fixed charges	$280 234	$56 860
Less value of purification plant	56 860	
Difference in favor of purification plant	$223 374	

COST OF WATER.

The cost of pumping water from Silver Lake may be compared with the cost of purifying and pumping the Salisbury Reservoir water, as follows:

Cost of pumping from Silver Lake, based on 1912, 1913, and 1914 records	$13.09 per million gal.
Cost of operation of purification plant and old pumping station:	
Coal	$1 950.00
Wages	2 000.00
Oil and waste	100.00
Repairs and miscellaneous	300.00
Per annum	$4 350.00

Per 1 000 000 gal.	$7.96
Chemicals per 1 000 000 gal.	5.01
Wash water at $9.00 per 1 000 000 gal.	.36
Superintendence	.55
Light and heat	.20
Repairs	.25
Total per 1 000 000 gal.	$14.33

Additional cost of Salisbury Brook Reservoir supply, purified and pumped .... $1.24 per mil. gal.
Additional annual cost of purifying 1 500 000 gal. daily $678.90
In eleven years, the extra cost capitalized at 4 per cent. would be equivalent to $9 525.00

Summary of Cost.

Cost of pipe line, 1927		$280 234.00
Cost of filters to 1927	$56 860.00	
Cost of filter operation and pumping at Brockton, to 1927, additional	9 525.00	
Total cost of filters and operation, to 1927		66 385.00
Saving over pipe line by 1927		$213 849.00

Location and Design of Purification Plant.

Figs. IV and III illustrate the proposed filtration plant for the Salisbury Brook Reservoir, which would be located on the old pumping station lot along the pipe line leading from the Salisbury Brook Reservoir.

The plant would consist of a coagulating basin having a capacity of 500 000 gal.; five filter units each having a capacity of 1 000 000 gal. daily, which would be arranged on both sides of a gallery which would contain the necessary filter piping and appurtenances; an elevated tank for the storage of wash water; a house to cover the operating room of the filters and to house the devices for applying chemicals to the unfiltered water, and a filtered water basin having a capacity of 500 000 gal., from which the present pumps would discharge the filtered water into the mains.

As the water came from the reservoir, it would receive a dose of chemicals; the treated water, after storage in the coagulating basin, would pass through the filters into the filtered water basin;

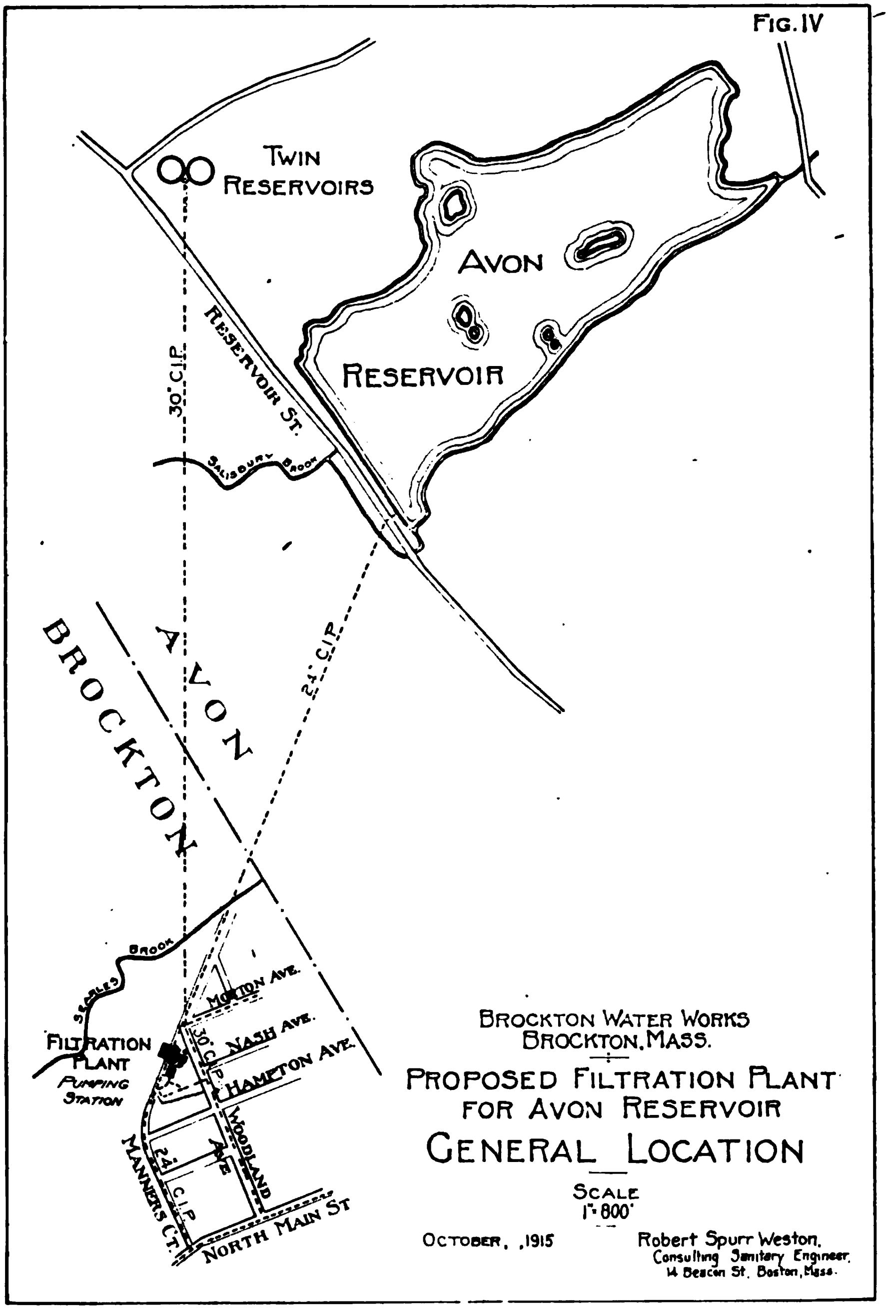
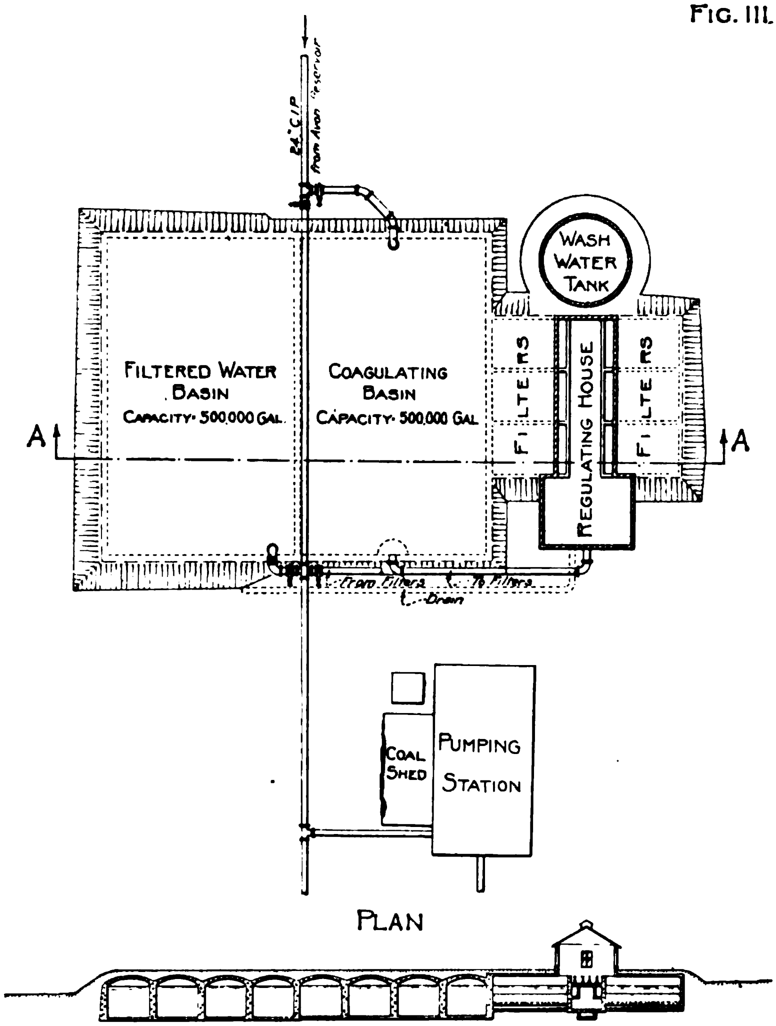


FIG. IV
TWIN RESERVOIRS
AVON RESERVOIR
RESERVOIR ST.
30" C.I.P.
24" C.I.P.
SALISBURY BROOK
AVON
BROCKTON
SEARLES BROOK
FILTRATION PLANT
PUMPING STATION
MORTON AVE.
NASH AVE.
HAMPTON AVE.
WOODLAND AVE
MANNERS CT.
NORTH MAIN ST
BROCKTON WATER WORKS
BROCKTON, MASS.
PROPOSED FILTRATION PLANT FOR AVON RESERVOIR
GENERAL LOCATION
SCALE
1" = 800'
OCTOBER, 1915
Robert Spurr Weston,
Consulting Sanitary Engineer,
14 Beacon St. Boston, Mass.

FIG. III.



SECTIONAL ELEVATION ON A-A

BROCKTON WATER WORKS,
BROCKTON, MASS.

PROPOSED FILTRATION PLANT
FOR AVON RESERVOIR

OCTOBER, 1915 SCALE 1"=40'

Robert Spurr Weston,
Consulting Sanitary Engineer,
14 Beacon St, Boston, Mass.

a small pump would lift about four per cent. of the filtered water into the wash water tank, from which the filters would be washed; the waste water containing the material washed from the filters would discharge into the drain.

No new or untried devices are contemplated in the design, but only what experience in other places has proved to be successful.

Practical Results.

As an example of what might be reasonably expected as a result, there is appended to this report a table showing the results obtained at Exeter, N. H. (during 1914), by a plant constructed by the writer in 1906, and consequently ten years old. This plant

Average Results of Analyses of Salisbury Brook Reservoir Water, 1910–1914, inclusive; also of Exeter, N. H., Reservoir Water, before and after Purification, for Year 1914.
(Parts per 100 000.)

Source.	Salisbury Brook Reservoir.	Exeter Water Works Reservoir.	Exeter Filtered Water.
Odor Hot	Ft. veg.	3.3–veg.	2.1–veg.
Odor Cold	Dec. veg.	1.3–veg.	0.1–veg.
Turbidity	V. slight	1.5	0.19
Color	0.52	0.56	0.07*
Oxygen consumed	.71	0.653	0.278
Nitrogen as free ammonia	.0032	0.0078	0.0099
Nitrogen as albuminoid ammonia	.0256	0.0307	0.0140
Nitrogen as nitrites	.0000	0.0000	0.0001
Nitrogen as nitrates	.0009	0.0054	0.0060
Chlorine	.47	0.547	0.572
Alkalinity	.. ..	1.67	0.95
Hardness	1.10	2.73	3.03
Iron	.038	0.049	0.013
Total residue on evaporation	4.54	7.56	7.26
Bacteria per c.c. at 20 degrees C.	......	293.	27.
Bacteria per c.c. at 37.5 degrees C.	......	139.	7.
Bacillus coli in 10 c.c.	......	None	None
Presumptive test for B. coli in 10 c.c.	......	37% Positive	Negative
Authority	Mass. St. Bd. of H.	R. S. W.	R. S. W.

* Experiments by Mr. Bolling show that the color of the Salisbury Brook Reservoir water may be reduced to 0.04.

treats a very bad water from a shallow reservoir. The conditions are worse than at Brockton, yet the color of the filtered water is reduced below that of Silver Lake.

SUMMARY AND CONCLUSIONS.

The present water supply from Silver Lake is excellent in quality. It is delivered through a pipe line 11.6 miles long, against a head of 340 ft. The present capacity of this pipe line is 6 000 000 gal., and is exceeded at times of maximum consumption. Either more distributing reservoirs or a new pipe line must be constructed, or the old Salisbury Reservoir must be used as an auxiliary.

The continuous average yield of Silver Lake is 3 500 000 gal. daily. The present population of Brockton, according to the state census, is 61 944; and the average daily consumption of water is about 3 201 000 gal. As reported by other engineers, the average consumption will exceed the average yield of Silver Lake by 1918, but by drawing down the lake 16 ft., thereby reducing the storage one half, the supply will meet the average consumption until 1927.

Because the present excellent quality of Silver Lake water depends upon its long storage, the lake should be kept as full as practicable.

Distributing reservoirs, like the two 4 000 000 gal. reservoirs in Avon, are excellent for meeting sudden fluctuations in consumption. They are too costly for furnishing an auxiliary water supply for several consecutive days. The same result may be accomplished better by an additional pipe line or by using the old source.

The Salisbury Brook Reservoir has a safe yield of 1 500 000 gal. daily, which, if filtered and used, would postpone adding to Silver Lake for four years beyond the time when the consumption would equal the safe yield of the lake, viz., 1931 instead of 1927.

Salisbury Brook Reservoir water, while safe to drink, is unfit for use in a city like Brockton unless it be decolorized. This can be accomplished only by treatment with sulphate of alumina, followed by filtration. The color of the water could be reduced below that of Silver Lake, as proved by the experience of many cities supplied with decolorized water. Filtration through sand without the addi-

tion of chemicals would reduce the average color from 0.52 to 0.31. The water would contain thrice as much color as Silver Lake water, a result which would neither satisfy the consumers nor warrant the cost of filtration.

A new 24-in. pipe line might be laid from Silver Lake, and would serve until 1930, when a third pipe line, 30 in. in diameter, would be required. The present pipe line can deliver 6 000 000 gal., or more than the safe yield of Silver Lake, and it seems illogical to further increase the pipe lines until after additions have to be made to Silver Lake, when one new main, 36 in. in diameter, equal to the probable capacity of the source with future additions, might be laid far more economically.

By using filtered Salisbury Reservoir water to make up deficiencies until additions must be made to Silver Lake, the lake may be kept more nearly full; the construction of new distributing reservoirs may be avoided; an auxiliary supply of 5 000 000 gal. daily for at least a month would be available at all times; the construction of a new pipe line could be postponed until 1927, or longer, if some of the water now going to waste in Avon be filtered and utilized, and the water supplied from the auxiliary source would equal Silver Lake water in color and in safeness.

The estimated construction cost of a 24-in. pipe line is $345 000; of a filter $70 000. The average cost of pumping water from Silver Lake is $13.09 per million gallons; the cost of purifying 1 500 000 gal. daily would be $14.33 per million gallons, or $1.24 per million gallons more. These differences, capitalized at the rates of interest prevailing in Brockton, show in 1927 a difference of $223 374 in favor of the purification plan.

The writer has recommended that the city construct a filter plant at the Brockton Pumping Station, as illustrated by the accompanying sketches, at a cost of $70 000, and postpone the construction of a pipe line until after the average daily consumption equals the average yield of Silver Lake plus the 1 500 000 gal. which may be drawn from the Salisbury Brook Reservoir. The purification plant should have a capacity of 1 500 000 gal. in eight hours, or the equivalent of the dry-weather yield of Salisbury Brook Reservoir, which reservoir should be kept full at all times, that the maximum amount of water may be held in reserve con-

stantly. It is also desirable, in order to maintain the quality of the water, that Silver Lake be kept as full as practicable. This may be accomplished by adding nearby sources in the future.

If the plant recommended be constructed, enough would be saved by the time further large improvements are required to pay a large part of their cost, and the cost of the purification plant as well.

DISCUSSION.

MR. GEORGE A. JOHNSON.* Mr. Weston's paper sets forth certain cardinal reasons why colored waters, like those of Salisbury Brook, are best decolorized by the use of chemicals and filtration through rapid sand filters. He has placed proper emphasis on the fact that while long storage in reservoirs will result in marked color reduction, water thus stored becomes an easy prey to the activities of micro-organisms, which impart to it offensive tastes and odors. Long storage is almost certain to be accompanied by stagnation of the lower strata, and if these layers are drawn upon for the supply, they require aëration before delivery to the consumers,

Mr. Weston also emphasizes the greater cost attending the decolorization of Salisbury Brook water by the use of coagulants and filtration through slow sand filters. This is a feature which has been found true in many other comparisons of like character, and is due chiefly to the necessity for large coagulating and sedimentation facilities, and to the greater cost of construction of slow sand filters of the same daily capacity as rapid sand filters.

FILTRATION FOR THE PHYSICAL IMPROVEMENT OF NEW ENGLAND WATERS.

As a rule, the waters of New England are comparatively free from turbidity, but many of them are quite deeply colored by vegetable stain. To remove these physical defects, filtration has been resorted to in many places. In a few cities, notably Brookline, Lowell, and Reading, Mass., iron removal is an important feature in the purification process.

* Consulting Hydraulic Engineer, New York.

MUNICIPAL WATER PURIFICATION PLANTS IN NEW ENGLAND.

Place.	Kind of Sand Filter.	Year Built.	Rated Daily Capacity, Million Gallons.	Chemicals Used.	Raw Water. (Parts per Million.) Color.	Alkalinity.	Hardness.
Bangor, Me.	Rapid	1912*	8.0	a-b	52	12	28
Belfast, Me.	Rapid	1913*	1.13	a-b	102	10	17
Biddeford, Me.	Rapid	1911*	10.0	a	33	4	20
Gardiner, Me.	Slow	......	......	......	...	..	..
Dover, N. H.	Slow	1909	1.2	None	...	..	..
Exeter, N. H.	Rapid	1906	1.0	a	50	15	30
Franklin, N. H.	Slow	......	......	.....	10	..	12
Lebanon, N. H.	Rapid	1907	1.0	a	12	..	16
West Lebanon, N. H.	Rapid	......	......	a	26	..	35
Somersworth, N. H.	Slow	1897	1.5	None	65	..	12
Burlington, Vt.	Rapid	1907	2.5	a	15	45	55
St. Johnsbury, Vt.	Slow	1897	2.5	None	...	..	..
Athol, Mass.	Rapid	......	1.5	a	35	..	11
Brookline, Mass.	Slow	1916	10.0	None	29	40	47
Cheshire, Mass.	......	1875	......	None	1	..	22
Cohasset, Mass.	Rapid	1914	0.5	None	44	30	16
Lawrence, Mass.	Slow	1893	6.0	None	25	..	15
Lowell, Mass.	Slow	1915	10.0	None	30	40	28
Marblehead, Mass.	Slow	1908	2.0	None	5	..	10
Middleboro, Mass.	Slow	1913	1.0	None	41	..	27
Milford, Mass.	......	......	......	......	20	..	29
Reading, Mass.	Rapid	1910	1.5	a-b	25	..	44
Springfield, Mass.	Slow	1909	15.0	a	36	10	14
W. Springfield, Mass.	Slow	......	1.0	None	12	..	36
Bristol-Warren, R. I.	Rapid	1908	3.0	a-b-c	50	10	27
E. Greenwich, R. I.	Rapid	1907	1.0	a-c	50	7	9
E. Providence, R. I.	Rapid	1893	3.0	a-c	50	12	24
Jamestown, R. I.	Rapid	1910	0.5	a-c	55	9	18
Newport, R. I.	Rapid	1910	3.0	a-c	40	19	29
Greenwich, Conn.	Rapid	1911*	4.5	a	38	15	30
New Haven, Conn.	Slow	1905	12.0	None	20	40	45
Norwich, Conn.	Rapid	1911	1.0	......	...	..	..
So. Norwalk, Conn.	Slow	1908	3.0	None	15	14	26
Providence, R. I.	Slow	1905	30.0	None	40	9	13

NOTES: a=alum; b=lime; c=soda.
* Newest installations.

In the accompanying table is given a fairly complete list of the municipal water filtration plants in New England. In addition to this list there are quite a number of many sizable rapid filter plants for the purification of waters for industrial use.

These data show that where color removal is aimed at, a coagulant, sulphate of aluminum, is almost always used. Where thoroughly good results in this direction are sought, it is the usual practice in New England, as elsewhere, to employ rapid sand filters, as distinguished from slow sand filters, in conjunction with the coagulating treatment.

Hygienic Efficiency of Rapid Sand Filters.

Aside from the obvious desirability of improving the appearance of public water supplies, by the removal of suspended matters and dissolved color, there is another phase of water purification of far greater importance. This refers to the removal from water of pathogenic bacterial life, particularly the typhoid fever germ.

The public in general senses but dimly the tremendous toll this country pays each year to that plague of filth, typhoid fever. Those of us who have never experienced this disease really think little about it, but the facts are all too plain that each year two hundred thousand people in America suffer from it, and twenty thousand die of it. In the course of a decade, therefore, one in every fifty inhabitants of this country contracts the disease.

Professor Sedgwick describes typhoid fever as a disease of defective civilization, since the widespread and frequent occurrence of this disease is due to defective sanitation; and defective sanitation means defective civilization. Unhappily, this is all too true. Typhoid fever cannot be contracted naturally without taking into the mouth the excrement of another human being, and this is done either by drinking water or milk which has been fouled by human excreta, by eating raw vegetables or other foods which have been contaminated in a similar manner, or by direct hand-to-mouth infection. The result of such practices, followed through ignorance of the possible results, or complacent tolerance by the public of unsanitary modes of living, is a heavy death toll which is entirely preventable, and which needlessly dissipates in vital capital $150 000 000 annually.

Twenty millions of people in the United States are now being furnished with filtered water at a cost not exceeding $8 000 000, or forty cents per capita, per year, and in the cities having filtered water supplies the water-borne typhoid has been practically eliminated, as reliable statistics abundantly show. Filtration of the water supplies of the remainder of the urban population of the United States would cost not more than $11 500 000 per year, and reliable statistics show that to do so would, at the very least, save thirty thousand typhoid cases and three thousand deaths each year, equivalent to vital capital in the total sum of $22 500 000 annually, or twice the money cost of prevention.

REDUCTION IN TYPHOID FEVER DEATH-RATES IN AMERICAN CITIES FOLLOWING THE FILTRATION OF THE PUBLIC WATER SUPPLIES.

(Averages for five years before and five years after filtration.)

City.	Kind of Filter.	Coagulant Used.	Average Typhoid Fever Death-Rate per 100 000 Population.		Per Cent. Reduction in Typhoid Fever Death-Rates which Followed the Filtration of the Public Water Supply.
			Before Filtration.	After Filtration.	
Albany, N. Y.	Slow	Yes	109	28	74
Charleston, S. C.	Rapid	Yes	106	62	41
Cincinnati, O.	Rapid	Yes	56	11	80
Columbus, O.	Rapid	Yes	83	17	78
Harrisburg, Pa.	Rapid	Yes	72	33	54
Hoboken, N. J.	Rapid	Yes	18	13	28
Indianapolis, Ind.	Slow	Yes	46	28	39
Lawrence, Mass.	Slow	No	110	23	79
Louisville, Ky.	Rapid	Yes	57	24	58
New Haven, Conn.	Slow	No	40	25	38
New Orleans, La.	Rapid	Yes	39	26	33
Paterson, N. J.	Rapid	Yes	29	9	69
Philadelphia, Pa.	Slow	Yes	63	20	68
Pittsburgh, Pa.	Slow	No	132	19	85
Providence, R. I.	Slow	No	19	13	31
Reading, Pa.	Slow	No	53	35	34
Scranton, Pa.	Rapid	Yes	25	10	60
Springfield, Mass.	Slow	Yes	22	22	0
Washington, D. C.	Slow	Yes	55	31	43
Wilmington, D. C.	Slow	Yes	35	24	31

The effect of water filtration on the typhoid fever death-rate is well understood, but, again to drive the point home, the speaker presents a tabular statement showing the actual experience in twenty representative cities of this country.

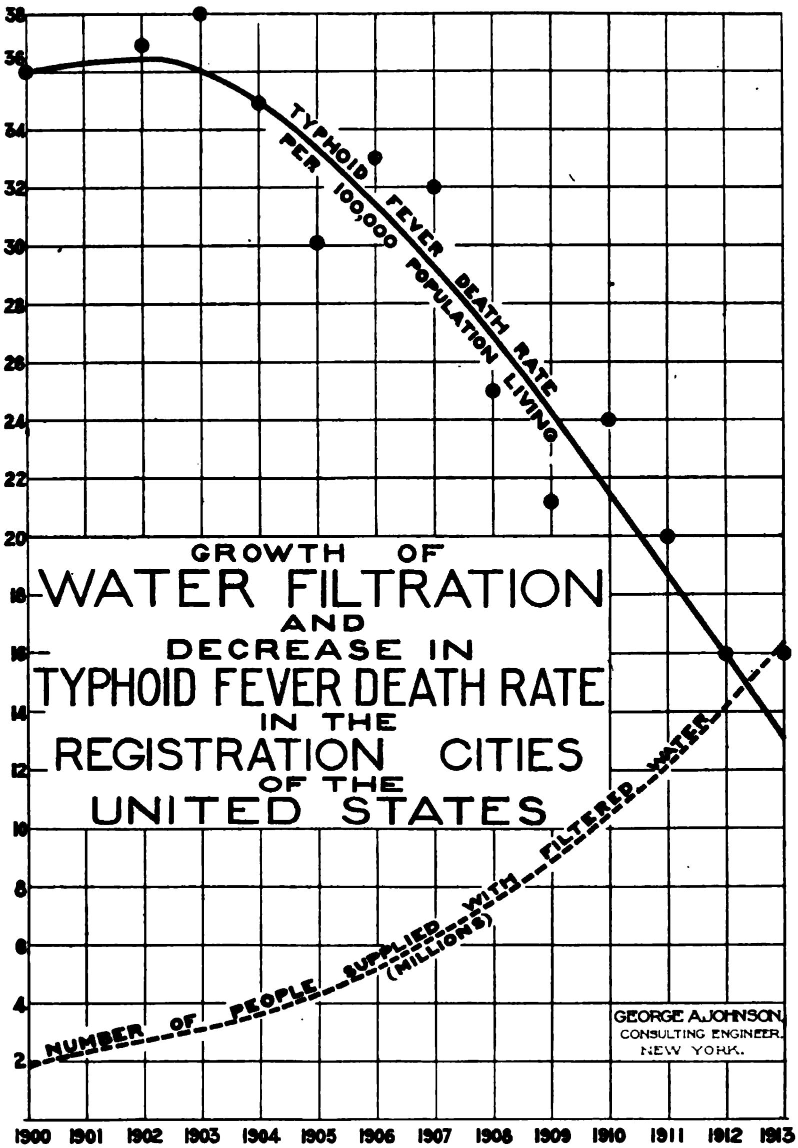
Among sanitarians there appears to be little if any dissension from the view that modern filtration practices actually eliminate the water-borne diseases, or typhoid fever and closely allied disorders at the very least. That is to say, where the plants are properly designed, well constructed, and intelligently operated, water filtration in practical terms is one hundred per cent. efficient.

The speaker next wishes to present some statistics to show how the typhoid fever death-rate, among the urban population of the United States, has decreased as water purification developed. The relationship between the two is strikingly proportional, and holds out every good promise for the future.

RELATIONSHIP BETWEEN THE INCREASE IN POPULATION SUPPLIED WITH FILTERED WATER AND THE DECREASE IN THE TYPHOID FEVER DEATH-RATE IN THE REGISTRATION CITIES OF THE UNITED STATES.

Year.	Population.		Per Cent. which Filtered Water Population was of		Typhoid Fever Death-Rate in Registration Cities.
	Total for Registration Cities.	Total in United States Supplied with Filtered Water.	Total Population of United States.	Total Population Registration Cities.	
1900	21 477 000	1 860 000	2.4	8.7	36
1901	22 146 000	2 400 000	3.1	10.8	34
1902	22 679 000	2 700 000	3.4	11.9	37
1903	23 221 000	3 100 000	3.8	13.3	38
1904	23 724 000	3 800 000	4.6	16.0	35
1905	24 729 000	4 300 000	5.1	17.4	30
1906	26 342 000	5 400 000	6.7	20.5	33
1907	27 145 000	6 300 000	7.2	23.2	32
1908	28 501 000	7 500 000	8.4	23.3	25
1909	29 655 000	8 900 000	9.8	30.1	21
1910	21 342 000	10 805 000	11.7	34.6	24
1911	32 376 000	12 000 000	12.8	37.2	20
1912	33 304 000	14 100 000	14.7	42.4	16
1913	34 230 000	16 500 000	17.0	48.0	16

Where a city takes its public water supply from surface streams and lakes, it is always liable to dangerous contamination at any


GROWTH OF
WATER FILTRATION
AND
DECREASE IN
TYPHOID FEVER DEATH RATE
IN THE
REGISTRATION CITIES
OF THE
UNITED STATES
TYPHOID FEVER DEATH RATE
PER 100,000 POPULATION LIVING
NUMBER OF PEOPLE SUPPLIED WITH FILTERED WATER
(MILLIONS)
GEORGE A. JOHNSON,
CONSULTING ENGINEER.
NEW YORK.
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
1900 1901 1902 1903 1904 1905 1906 1907 1908 1909 1910 1911 1912 1913

time. Strict sanitary patrol of the watershed will tend to prevent gross pollution and minimize the danger, but it will not eliminate it entirely. Merely because a city for years has enjoyed a very low typhoid fever death-rate while continuing to use a surface water supply without purification, is no reasonable assurance that at any time the supply may not become contaminated and cause an epidemic among the consumers. No unpurified surface water supply is entirely safe to drink, and on hygienic grounds alone water purification will always show a substantial balance on the right side of the ledger. Where one dollar is spent for pure water, many dollars are saved in the form of vital capital through the prevention of sickness and death. If a community of 19 000 people spends each year forty cents per capita for filtered water, and thus each year prevents a single death and the attendant ten cases of illness from typhoid fever, it will come out even financially, and increase its self-respect into the bargain.

REPORT OF COMMITTEE ON METER RATES.

[*Presented February 9, 1916.*]

(Subject to Revision.)

TO THE NEW ENGLAND WATER WORKS ASSOCIATION:

Your Committee on Meter Rates, having presented a preliminary report in September, 1914,* and having had the benefit of such discussion as has taken place by members of the Association, now presents its final report.

Your Committee has prepared a standard form for Meter Rates. This is given in alternate forms, according as gallons or cubic feet are used, and as the unit of time is annual, quarterly, or monthly. The schedules are as follows:

QUANTITIES IN GALLONS. BILLS ANNUALLY.

For each service supplied by $\frac{5}{8}$-in. meter there shall be a charge for the service and meter per annum, of	$..........
In addition thereto, for all water drawn there shall be charged:	Per 1 000 gal.
For the first 300 000 gal. of water per annum, or any part thereof, the DOMESTIC RATE of	$..........
For water in excess of 300 000 gal. and under 3 000 000 gal. per annum, the INTERMEDIATE RATE of	$..........
For water in excess of 3 000 000 gal. per annum, the MANUFACTURING RATE of	$..........

QUANTITIES IN GALLONS. BILLS QUARTERLY.

For each service supplied by $\frac{5}{8}$-in. meter there shall be a charge for the service and meter per quarter, of	$..........
In addition thereto, for all water drawn there shall be charged:	Per 1 000 gal.
For the first 75 000 gal. of water per quarter, or any part thereof, the DOMESTIC RATE of	$..........
For water in excess of 75 000 gal. and under 750 000 gal. per quarter, the INTERMEDIATE RATE of	$..........
For water in excess of 750 000 gal. per quarter, the MANUFACTURING RATE of	$..........

* JOURNAL N. E. W. W. A., Vol. 28, 199 (1914).

QUANTITIES IN GALLONS. BILLS MONTHLY.

For each service supplied by $\frac{5}{8}$-in. meter there shall be a charge for the service and meter per month, of	$..........
In addition thereto, for all water drawn there shall be charged:	Per 1 000 gal.
For the first 25 000 gal. of water per month or any part thereof, the DOMESTIC RATE of	$..........
For water in excess of 25 000 gal. and under 250 000 gal. per month, the INTERMEDIATE RATE of	$..........
For water in excess of 250,000 gal. per month, the MANUFACTURING RATE of	$..........

QUANTITIES IN CUBIC FEET. BILLS QUARTERLY.

For each service supplied by $\frac{5}{8}$-in. meter there shall be a charge for the service and meter per quarter, of	$..........
In addition thereto, for all water drawn there shall be charged:	Per 100 cu. ft.
For the first 10 000 cu. ft. of water per quarter or any part thereof, thereof, the DOMESTIC RATE of	$..........
For water in excess of 10 000 cu. ft. and under 100 000 cu. ft. per quarter, the INTERMEDIATE RATE of	$..........
For water in excess of 100 000 cu. ft. per quarter, the MANUFACTURING RATE of	$..........

QUANTITIES IN CUBIC FEET. BILLS MONTHLY.

For each service supplied by $\frac{5}{8}$-in. meter there shall be a charge for the service and meter per month, of	$..........
In addition thereto, for all water drawn there shall be charged:	Per 100 cu. ft.
For the first 3 300 cu. ft. of water per month, or any part thereof, the DOMESTIC RATE of	$..........
For water in excess of 3 300 cu. ft. and under 33 000 cu. ft. per month, the INTERMEDIATE RATE of	$..........
For water in excess of 33 000 cu. ft. per month, the MANUFACTURING RATE of	$..........

The prices to be written in the schedule should be fixed in each case by the local authorities to meet local conditions and to produce the required revenue, and the committee makes no suggestion as to how great they should be. It suggests, however, that the methods of determining the service charge and the rates for each class of water should follow those outlined in its preliminary report.

For a domestic service with ⅝-in. meter, the ordinary service charge may properly be about $3 per annum where service and meter are paid for by the taker; $4 where the meter is furnished by the works, and $5 or $6 where both meter and service pipe are paid for by the works, the lower figure being used where the average cost of the service pipe is under $15, and the higher where it is greater than $15. The above charges, however, are subject to modification, depending upon local conditions, and in general the method of fixing them should be that laid down in the preliminary report of this committee.

It is recommended that the price per 1 000 gal. or per 100 cu. ft. be in most cases an even number of cents, omitting fractions, and that the domestic rate and manufacturing rate be first fixed; that the manufacturing rate should very seldom be less than half of the domestic rate, and that for the intermediate rate the price be to the nearest cent midway between the average and the mean proportional of the domestic rate and the manufacturing rate. In other words, it will ordinarily be half-way between the two, or half-way between the two less one-half cent.

The minimum charges for services with meters larger than ⅝-in. may be fixed at larger sums, to be computed by the methods indicated in the preliminary report.

A flat rate for all quantities may be made by fixing the same price for water for domestic purposes and for manufacturing purposes, and in this event the whole schedule may be simplified.

The committee further recommends that where the same works supply water in different services under conditions which impose substantially greater relative expense in one or more such services as compared with others, by reason of high-service pumping or otherwise, that it is just and equitable that discriminations be made and that for water sold in such districts the additional cost may be approximately ascertained and an added price may be charged for water sold in such districts.

For example, to one of the schedules as drawn above might be added the words:

"For all water sold in the high-service district the charges shall be..........cents per 1 000 gal. (or per 100 cu. ft.) greater than those in the above schedule."

The committee recommends that statistics of sales of water by meter be classified on the basis that is used in the preparation of the rates schedule, and suggests that this can be done for any water-works system, even though the meter rates are not in the form recommended. The classification might appropriately be in this form:

STATISTICS OF.........................WATER WORKS FOR YEAR........

	Services coming entirely under DOMESTIC RATES, that is, averaging less than 820 gal. per day.	Services coming under INTERMEDIATE RATES, that is, averaging between 820 to 8 200 gal. per day.	Services securing MANUFACTURING RATES, that is, using an average of more than 8 200 gal. per day.	Total.
Number of services.....				
Total amount of water supplied to these services. Millions of gallons................				
Total amount of revenue derived from these services. Dollars.......				

The above constitutes all the underlying data that are necessary. From them the amount of water that would be sold under each of the rates, if a rate in the form now recommended were adopted, can be readily ascertained, and also the present revenue derived therefrom. From these the average present receipts from water quantities sold within these limits can be determined. With this information, the rates in the form recommended by your committee that would produce the same amount of revenue as present rates, in any case, can be ascertained.

Compiling statistics in this form will further permit comparison of meter rates now in use under schedules which do not permit direct comparisons to be readily made, and will facilitate such comparisons on an accurate and uniform basis.

The committee calls attention to the chart prepared by it, and to be obtained in quantities from the Secretary, as a convenient means for plotting and comparing various meter rates.

The committee recommends that the form for rates now presented be adopted by the Association as a standard.

The committee further reports that the other matters referred to it, relating to the study of waste of water, are still under consideration. As these matters are not in any way related to those first referred to the committee, the committee now reports on its primary work, which is complete, and asks for further time in reporting upon the other matters.

ALLEN HAZEN, *Chairman*,
A. W. CUDDEBACK,
A. E. BLACKMER,
JAMES L. TIGHE,
CHARLES R. BETTES,
PHILANDER BETTS,
Committee on Meter Rates.

DISCUSSION.

MR. C. W. SHERMAN.* I move that this report be accepted, and that the committee's recommendation as to the adoption of the form for making out meter rates be adopted as the standard of the Association.

(The motion is seconded by Mr. C. M. Saville.)

MR. G. A. KING.† Mr. President, would it not be well for the Association to know what those recommendations are a little more than we can know now? Should they not be printed and sent to the members and then action taken on them?

MR. SHERMAN. It seems to me, Mr. President, that the Association would not commit itself to anything that might in any way work out unfortunately in adopting this as a standard, and until something is adopted as a standard there is not much likelihood of getting it used. If, after a year or two, there is any possibility of improving it, it would not be a difficult matter to amend

* Of Metcalf & Eddy, Boston.
† Superintendent Water Works, Taunton, Mass.

it. The prime thing, as I see it, is a method of arranging these things as a standard method. The committee does not in any way recommend the prices that should be put in; that should be fixed by each place independently.

MR. FRANK L. FULLER.* I agree with Mr. King that we ought to have a chance to study these rates before we vote to adopt them. I think that at a subsequent meeting the motion would be in order.

MR. MAURICE R. SCHARFF.† In addition to the desirability of giving further study to this schedule, and possibly the reading of this committee report, it seems to me there are at least one or two rather important criticisms that may be made of the schedule as presented that ought to be given consideration, careful consideration, before this Association commits itself to this form of schedule. I will refer to those as briefly as I can.

The general form of the schedule I believe is very excellent indeed, and I, for one, am pleased to see a schedule recommended in the form of a service charge without any allowance of water, and a sliding scale meter rate. But the service charge recommended, amounting to from three to six dollars per annum, is evidently based wholly upon the assumption that the consumer is to pay the fixed charges upon the cost of the meter and service connection only. Now, it seems to me that the idea of a rate schedule is, in the first place, to distribute the cost of maintaining a water-works plant among consumers somewhat in proportion as they contribute to that cost, and the idea of making a division between a service charge and a meter charge is primarily to assess by meter charge those costs which depend more or less directly upon the amount of water consumed, and to assess by a service charge those costs which are wholly independent of the amount of water consumed. Now, it is obvious that in addition to the fixed charges upon the meter and connection, the fixed charges upon a very large portion of the water-works plant, including the entire distribution system and considerable portions of the supply works, are wholly independent of the amount of water consumed by the connected consumers and dependent wholly upon the

* Civil Engineer, Boston.

† Pittsburgh, Pa.

demands thrown upon the system by those consumers. I believe, therefore, that a service charge which contains no allowance for water consumed but which is sufficiently large so that the consumer shall pay his fair proportion of all of the charges which he occasions to the water works by his connection, and which will include the fixed charges upon the plant for supplying the water and distributing it to him, would be fairer and better adapted to practical use in the long run than such a small service charge as is here suggested.

Another disadvantage of the small service charge here suggested is that all of these additional fixed charges to which I have referred are transferred into the meter rate, which is thereby made so much higher. The direct result of this is to penalize the long-hour high-load factor consumer, who uses water perhaps twenty-four hours per day at a more or less uniform rate, the most desirable type of consumer, and the one to whom the water works can best afford to make concession in order to retain; and by raising the meter rate and holding down the service charge, to reward the low-load factor short-hour consumer, who is the most expensive consumer to supply.

One other criticism of the schedule that may be made is that it seems to me it is entirely too definite with respect to suggesting the rates of consumption which shall be adopted as the dividing lines between the several steps of the sliding scale. To my mind, the justification of a sliding scale of meter rates is the fact that a water-works plant, although it may have the monopoly of the supply of water in a given territory, is nevertheless placed in competition with other possible sources of supply whenever it comes to supply a consumer large enough so that a separate supply system becomes an economic possibility. And the justification for the sliding scale of rates is the necessity of making concessions to such large consumers so that they may obtain water at something approaching the price at which they might obtain it if they put in independent supplies of their own. In other words, we have here exactly the same problem of rate making that the electric light and power companies have to face in going into the market and attempting to displace isolated power plants. That being the case, the so-called manufacturing rate or lower step of the

sliding scale schedule should depend, I think, entirely upon the local conditions with respect to the availability of other sources of supply and the number and character of large consumers who have to be considered as possibly going to other competitive sources of supply.

For those reasons it seems to me entirely impractical to fix in any standard form either the rates of consumption which should be considered as the proper dividing lines between the several steps of the schedule or the ratio between the maximum and minimum rates of the schedule, as is suggested in this report. And not only do I think it wise that further consideration should be given to the report before it is adopted, but it appears to me very unwise that it should be adopted unless some changes along these two lines should first be made.

MR. SHERMAN. I am hardly in a position to be arguing for the committee, not being a member of it and not having seen the report before I read it. But I think Mr. Scharff's first criticism is made under some misapprehension of what the report says. While they do suggest that the method of fixing the service charge might very properly follow the method outlined in their preliminary report, and be based, as Mr. Scharff says, on the fixed charges on service pipe or meter, they do not at all specify it in the standard form of rates, and the Association by accepting the suggested form as a standard would not accept that method of fixing the service charge. That would be left to be fixed by each water department for itself. The specific wording here is, "It suggests, however, that the method of determining the service charge and the rates for each class of water should follow those outlined in its preliminary report." That does not, however, make them a part of the standard method of rating.

The other point raised by Mr. Scharff, that of the points of division between domestic, intermediate, and manufacturing rates, is, of course, fixed in their recommendation, and must be fixed if anything is to be taken as a standard. It does not seem to me that that is necessarily an argument against it. The committee, at least in its preliminary report, recognized fully that local conditions might in some cases make any such standard as they recommend impractical. And unquestionably where local

conditions call for something different than would conform to the standards, the local conditions should govern. But there are a great many cases where there is no particular reason where any convenient point should not be considered the dividing line, and for all such cases it would seem desirable that such a standard be adopted. Certainly we can make no comparison of quantities of water used under the different charges, or of what the changes in revenue would be for certain changes in charges, unless we have some definite division point for what may be considered standard rates.

Under these circumstances, and bearing in mind that the committee does not recommend as part of its standard what the service charge should be, but merely suggests a method which seems to them a reasonable way of getting at it, and that while this matter of dividing the different classes of charges may not be applicable in all cases, it still probably is in a large percentage of them, and if anything is to be standard it has got to be adopted by somebody, and I think our committee is as well qualified to judge what those points are as any committee could be, — I think there is no reason yet advanced why the Association should not adopt this.

MR. MARTIN.* I think there is one reason why we should postpone this matter to the next meeting, and that is the lack of members present. The members have drifted out. There are perhaps not more than half as many here as there would be if we take it up at the beginning of the next meeting. It seems to me that it would be a good scheme to have this report printed and forwarded to the members with the notice of the next meeting, and then have it taken up with a full membership and discussed, if it is necessary to discuss it, and, if not, have it voted on when there are enough here to know just what is going on. I offer that suggestion.

MR. KING. Mr. President, I move that as a substitute motion to Mr. Sherman's, that it be printed and sent to members and action taken at the next meeting.

MR. SHERMAN. That is entirely acceptable, Mr. President.

PRESIDENT SULLIVAN. Then it is made as a motion, as stated by Mr. Martin, that it be printed and sent to members and be

* Superintendent of Water Works, Springfield, Mass.

discussed at the beginning of the next meeting. The other motion is withdrawn, if there is no objection. Is there anything to be said on that motion?

(The motion is adopted.)

Discussion at Meeting of February, 1916.

Mr. Allen Hazen * (*by letter*). The application of the methods proposed by the committee to the rates of a specific system may be helpful. It is proposed to find a new rate conforming to the committee's recommendation that will produce the same revenue that is produced by present rates.

The plant selected for this study is a small one, with 4 958 meters and a few unmetered services which are not brought into this study. Waste has been persistently hunted for years, and the per capita consumption is unusually low.

On Fig. 1 a solid line shows the present rates. On the same sheet are drawn three other solid lines, which together show the annual bills up to $5 000 per annum for all quantities of water drawn. These total-bill lines are easily drawn on the meter-rate sheet of the committee, and add considerably to the convenience of the study.

The meter rates for this plant, from a scientific standpoint, are bad. They advance by irregular steps. It is sometimes possible to get a lower bill by drawing more water. The rates for the largest consumers are too low, and for certain intermediate ones they are too high. The schedule, however, is fixed by contract, has successfully withstood attacks, and is a good revenue producer. It is certain that it will not soon be changed, but we may, nevertheless, see what could be done to improve it if conditions permitted.

An analysis of the records for the last year shows that 4 839 of the services drew less than 300 000 gal. each. On the proposed classification all water drawn by them would come under the Domestic Rate. These services drew in the aggregate 150 000 000 gal. of water, an average of 85 gal. per day for each service. Among the larger services there were 99 drawing larger quantities

* Civil Engineer, New York.

but less than 3 000 000 gal. each, and therefore coming under the Intermediate Rate. These drew, in all, 47.7 million gallons, an

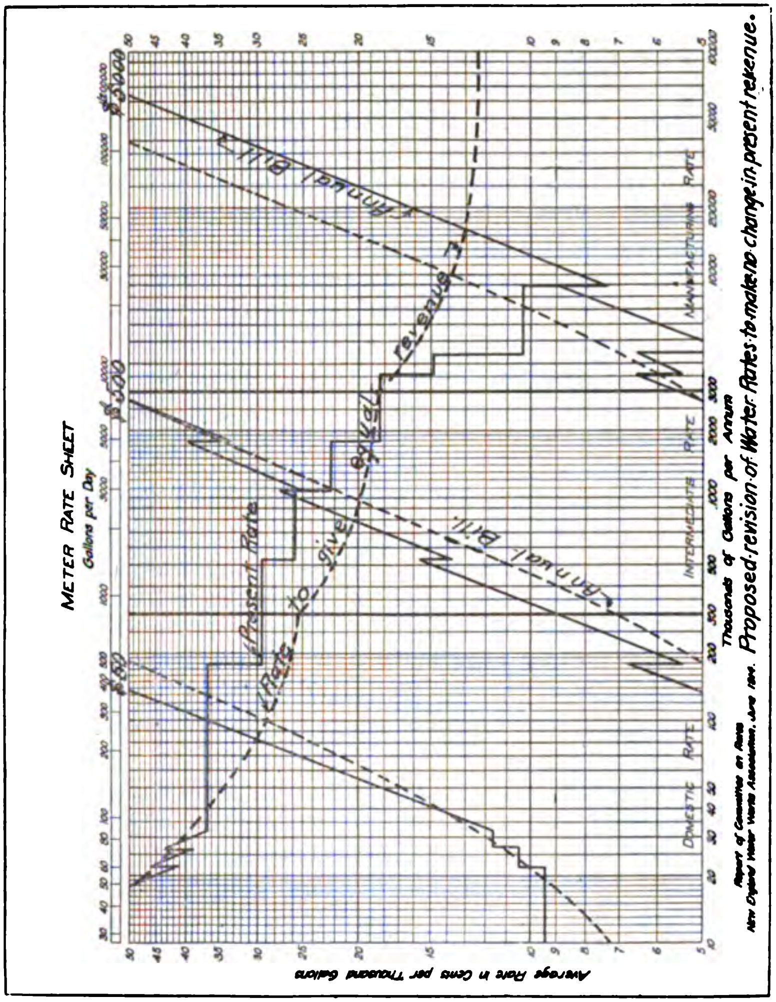


FIG. 1.

average of 1 320 gal. per day for each service. Of this amount, 300 000 gal. from each service during the year, or 29.7 million

gallons, would be charged at the Domestic Rate. The remaining 18 000 000 gal. drawn by these 99 services would be charged at the Intermediate Rate. There were, further, 20 services drawing over 3 000 000 gal. each, and so coming under the proposed Manufacturing Rate. The total draft by these was 143.3 million gallons, an average of 20 000 gal. daily for each service. Of the whole quantity drawn by these 20 services, 6 000 000 gal. would be charged at the Domestic Rate, 54 000 000 gal. at the Intermediate Rate, and the remaining 83.3 million gallons at the Manufacturing Rate. Bringing these quantities together for the whole system, it is found that 341 million gallons were sold, of which 185.7 million gallons, or 54.45 per cent., would be charged at the Domestic Rate; 72 million gallons, or 21.12 per cent., would be charged at the Intermediate Rate; and 83.3 million gallons, or 24.43 per cent., would be charged at the Manufacturing Rate.

The service charge for local conditions, computed as suggested in the committee's report, is found to be 40 cents per month, or $4.80 per annum, for a ⅝-in. service. For 4 958 services, this amounts to $23 800. About 3 per cent. of the services are larger and would pay a greater service charge. Approximately, 5 per cent. would be added, and the total amount produced by the service charge would be $25 000.

The actual revenue from the sale of water was $91 226. Deducting the amount that would have been raised by the service charge, if it had been in effect, leaves $66 226 to be charged for water.

The slide in the present scale exceeds the 2 to 1 ratio which the committee suggests as the ordinary maximum. In finding new rates, it is proposed to reduce the amount of slide to the 2 to 1 limit. The calculation will be made by first applying assumed rates which are in this proportion and determining what these rates would have produced and how much they would have to be increased to produce the desired revenue. It makes no difference what rates are assumed for the first calculation, so long as they are in the right proportion; 20, 14.6, and 10 cents per 1 000 gal. will be used. At these rates the revenue that would have been derived is as follows:

185.7 million gallons @ 20¢	$37 140
72 million gallons @ 14.6¢	10 510
83.3 million gallons @ 10¢	8 330
Total	$55 980

The required sales to equal present revenue as found above is $66 226, or 18.3 per cent. more than the amount found by this trial. The assumed rates must, therefore, be raised by 18.3 per cent. So corrected, they are found to be 11.83, 17.27, and 23.66 cents per 1 000 gal. As cubic feet are used, the corresponding values are found to be 8.87, 12.95, and 17.75 cents per 100 cu. ft. The round figures 9, 13, and 18 are sufficiently close and may be used.

As the bills are rendered monthly, the quantity figures in the committee's schedule are divided by 12 (months in a year) and by 7.5 (gallons in a cubic foot), and the schedule with the blanks filled in is as follows:

For each service supplied by ⅝-in. meter there shall be a charge for the service and meter per month of	40¢
In addition thereto, for all water drawn there shall be charged:	Per 100 cu. ft.
For the first 3 300 cu. ft. of water per month, or any part thereof, the Domestic Rate of	18¢
For water in excess of 3 300 cu. ft. and under 33 000 cu. ft. per month, the Intermediate Rate of	13¢
For water in excess of 33 000 cu. ft. per month, the Manufacturing Rate of	9¢

On Fig. 1 the rates corresponding to this schedule are plotted as a dotted line. The annual bills are also shown. These dotted lines show a schedule of rates that conforms to the committee's recommendation in all respects and that would have produced the same revenue for this plant as the present rates shown by solid lines actually did produce for the record year.

This plotting shows clearly just which classes of consumers would have their rates raised and which would have their rates lowered. It is interesting to note that consumers drawing from 50 to 150 gal. per day on an average, these, being two thirds of the whole number, would not be greatly affected by the change.

There is a further comparison that may be made and that has some interest in this case. On page 212 * of the printed report is given a representative rate in the form proposed by the committee that in a general way is found to correspond approximately with current practice of American cities that have adopted the meter system. If this schedule had been in effect at the plant in question during the past year, the charges under it would have been as follows:

Service charge for 4 958 services @ $4.20 (=$3.00+$1.20) . . .	$20 700
Add approximately for larger services 5%	1 000
185.7 million gallons of water @ 21¢	39 100
72 million gallons of water @ 16¢	11 500
83.3 million gallons of water @ 11¢	9 200
Total revenue at this rate	81 700

The actual revenue from the sale of water was $91 226, which is 11.7 per cent. more than the sum that would have been received by the above-mentioned rates. It is thus ascertained that the actual rates of this company produced a revenue that is about 12 per cent. greater than the average or representative rate as above defined would have done.

The writer fully concurs in a great deal of what Mr. Scharff says in regard to the service charge, but he thinks that there is one substantial element in the situation which has been overlooked by Mr. Scharff, and which makes it undesirable and impracticable to greatly increase the service charge.

In a normal, completely metered water-works system, 90 per cent., more or less, of all the takers are served by ⅝-in. meters and services. The smallest cottages and houses of considerable size are supplied through pipes of the same size. A service of this size is practically large enough to take care of most of the takers, and there are practical reasons why it would not be wise to increase the size of the service pipe unnecessarily. On the other hand, practical considerations do not warrant reducing the size of the pipe to the smallest houses.

If the whole amount that might, in the aggregate, be assessed in service charges against all the houses could be equitably assessed on the several houses in proportion to the facilities for the use

* JOURNAL N. E. W. W. A., Vol. 28 (1914).

of water in them, there would be considerable merit in the procedure of assessing the full amount in that way. The small cottage would then pay a small service charge, and a good-sized house would pay a much larger service charge, even though the size of the pipe and meter were the same.

Practically it would be very difficult to apply such a system of grading service charges, and it was not seriously considered by the committee.

To divide the whole amount that might be placed on service charges by the number of services, and to distribute it equally, is doing a substantial injustice to the smallest takers, and lets the larger houses off at less than their fair share of cost.

The way that the matter is practically carried out at the present time in a majority of American cities is to assess the extra cost that might be attributed to service charge by theoretical segregation in the form of an additional price per thousand gallons on certain quantities of water that are first drawn from each service. This gives rise to the sliding scale. This procedure distributes the said charges, or so much of them as are represented by the higher rates, among the different consumers in proportion to the quantities of water that are drawn. The procedure probably does not put all the extra charges exactly where they should best go, but in a broad, general way the writer believes that it distributes them approximately in an equitable manner, and that the general procedure outlined by the Committee's report will result in a more equitable distribution of all the burden among the takers than would result from the use of a much higher service charge, and the elimination of all, or a part of the excess charge on the first quantities of water drawn.

The writer believes that the present average practice of American water works is pretty nearly right in regard to this matter, and the Committee's work accepts this, but proposes to standardize it; and the adoption of the Committee's reports will tend to line up rates and to eliminate many erratic rates now in force.

The writer also notes the suggestion that the points at which change in rates should take place should be differently selected for different communities. No doubt there would be here and there local conditions that might tend to modify somewhat the points that

might be selected if local data only were considered. This would relate mainly to special rates for very large quantities, in making which some flexibility in procedure may be desirable. And such flexibility is not inconsistent with the procedure proposed by the committee for all smaller services. On the other hand, generally speaking, the conditions of service in American cities are tolerably uniform, and the writer believes that it is for the good of the service that the points for change in rates should be standardized. This will permit direct comparison between different systems, and will give stability and definiteness to the business that is now sadly lacking.

PHILANDER BETTS, Ph.D.* (*by letter*). In making this addition to the discussion of this subject, I do not wish to be understood as taking issue with any of the other members of the committee. My feeling is that the report of the committee is practically the resultant work of the committee as a whole, but I wish to call attention to a somewhat different method of treating this subject which was originally set out by Hopkinson in England, and by Henry L. Doherty in this country treating of rates for electricity supply.

FORM OF RATE SCHEDULES.

There is an increasing realization on the part of the management of public utilities that all schedules of rates should be so designed as to properly distribute the costs upon those who benefit by them. Any failure to do so is, to a greater or less extent, an unjustifiable discrimination.

Any system of rates which results in relieving any considerable proportion of customers from their just burdens only serves to load on others a burden which they should not be asked to bear.

The cost of central station service can be generally divided into three classes:

(1) Those elements of cost which are strictly proportional to the number of customers, such as billing, meter reading, accounting, collecting, meter testing, etc.

(2) Those elements of cost which are proportionate to the maximum demand which a customer may make upon the plant and system of the public utility.

* Fellow, American Institute of Electrical Engineers; Member, American Society of Mechanical Engineers.

(3) Those elements of cost which are in proportion to the actual amount of water, gas, or electricity actually used.

Any system of rates which omits from proper consideration any great proportion of the costs referred to above results in an overcharge to some and too great liberality to others.

In the following Table 1, an attempt has been made to allocate all of the expenses for a given year to the appropriate class of

TABLE 1.

EXPENSES IN CONNECTION WITH SERVICE TO

Item.	$300 000.			$60 000.		
	Private Customers.			Fire Protection.		
	Class 1.	Class 2.	Class 3.	Class 1.	Class 2.	Class 3.
Profit, 7 per cent		$21 000.00			$4 200.00	
Taxes — [illegible] plus [illegible]		2 370.00			395.00	
Administration	$1 000.00	722.42		$8.45		
Interest temporary loans			$435.70			
Insurance		403.04			67.17	
Stationery and stamps	361.88					
Telephones	113.29		100.00			
Other office expenses	69.43					
Wages, clerks, etc.	1 305.50					
Wages, outside	450.17	100.00	200.00		100.00	
Legal expenses	100.00	105.00				
Tools			90.11			
Automobile maintenance	397.67	100.00	400.00			
Painting and repairing standpipe		871.23			145.20	
Painting and repairing hydrants					128.93	
Painting and repairing meters	240.78					
Painting and repairing buildings		178.42				
Painting and repairing pipe lines		60.79	600.00			$100.00
Miscellaneous expenses	195.79	200.00	250.00		50.00	
Depreciation		4 139.65			700.00	
Pumping:						
Wages			912.97			
Fuel			2 526.30			
Oil, waste, packing			145.71			
Lighting stations			62.11			
Repairing machinery			181.68			
Miscellaneous expenses			133.46			
	$4 234.51	$30 250.55	$6 038.04	$8.45	$5 786.30	$100.00
		$40 523.10			$5 894.75	

Per customer	$2.22	Per hydrant:
Per demand unit	12.06	214) 5 894.75
Per gal. pumped	7.2c	$27.54
Total customers	1 905	
Total gal. pumped	84 000 000	
Total demand units	2 507	

costs. These figures are taken from the actual operating expenses of one of the New Jersey seashore companies.

It will be noted that depreciation and interest are all put in the second class of costs. The reason for this is that at the present time rates of return and rates for depreciation are based upon the investment, and do not take into account the efficiency in operation. It may be, in the last analysis, that we ought to base part of our profit on the amount of the investment and part of it on the efficiency in management. This would throw a portion of our profit into the third class of expenses.

In the analysis referred to, it will be noted that the expenses have been divided into two general classes, — those referring to fire protection and those referring to the cost of furnishing the service to private consumers. The method of division of the investment for this purpose is not up for discussion at this time, and I will not refer to my reasons for dividing the investment in the way I have. It will be noted at the head of this table that I have allotted an investment of \$60 000 to the fire protection, and an investment of \$300 000 to private consumers.

In the table it will be noted that the amount charged in connection with fire protection is \$5 894.75. As there were in use 214 hydrants, the unit cost per hydrant was \$27.54. The contract price paid by the municipality was \$25 per hydrant. The relation between these figures shows that the municipality should pay at a somewhat greater rate for hydrant service under the present conditions. Their failure to do so throws some of these costs on consumers generally.

With reference to private customers, at the time under discussion, there were approximately 1 905 customers carried on the books of the company. Table 1 shows that the Class 1 expenses amounted to \$4 234.51. This gives as the unit cost per customer for Class 1 expenses, \$2.22. With reference to the division of Class 2 expenses over the various classes of customers, some consideration must be given to the methods for determining the maximum demand made by each customer.

In deciding upon the method to be adopted in measuring the demand which each customer may make upon the plant of a water company, we meet with considerable difficulty. In the earlier

days, water was supplied at flat rates, these rates being based upon an assumed demand, although demand and consumption were in general considered to be the same thing by the companies.

Demand indicates the draft or requirement a customer *can* make momentarily; *consumption* indicates the actual amount he does draw in the course of time. Flat rates for water supply were made up by adding together charges of an arbitrary amount for each one of various kinds of fixtures, each additional fixture carrying with it an additional charge. In some cases, water rates have been computed in proportion to the width of the lot occupied by the building supplied. This, however, has mainly been true in connection with municipally operated supplies. Charges have also been computed by the square feet of floor area in a building; they have also been computed by making allowances of a certain amount for each sleeping room, this being an assumption that the number of sleeping rooms was a measure of the number of occupants in a building, and in turn the number of occupants was the best measure of the use of water.

In recent years, flat rates have been based upon the number and character of the fixtures. It will readily be seen that the methods of charging referred to would lead to great inconsistencies, due to the fact that some persons will use a very much greater quantity of water than others occupying premises equipped in exactly the same way. These inconsistencies have led to complaints, and the final result has been the adoption of meters in a great many of our communities. In some places, meters are used in connection with every customer; in others, meters are only used where the conditions are peculiar and where flat rates lead to great inequality in the treatment of its customers.

It has been stated above that costs for service may be generally divided into three classes, and with such a division no one will disagree, although there may not be entire agreement as to the method of classifying the various kinds of expenses. This being true, it will be equally obvious that any system of rates based upon a uniform charge per unit of product, without any other element in the rate schedule, or without a minimum charge, to say the least, could not help but relieve some customers of charges which they should properly bear.

The problem before us is to ascertain how we may determine the demand that may be made by each customer upon the plant and distribution system of the water company. The size of the meter and the size of the service pipe, if correctly proportioned to the fixtures installed in a building, appear to be the best index for determining the demand. Such methods are common in connection with electric light schedules, but with water supply the conditions are somewhat different from those of electric light plants.

With electric-lighting service, there are available maximum demand meters, which measure, as the name implies, the maximum demand made by the customer, that is, the maximum demand for current at any one time.

With regard to water supply, there is no such instrument available as a meter registering the maximum demand at any particular time, and even if it were available, it might not be a true index of the proper demand charge to be made against a given customer, due to the fact that the water user can usually wait a few moments if the demand for water is too great either in his own building or in the immediate vicinity. Further, water can be stored in tanks in buildings, and can be supplied with some degree of uniformity to the fixtures in the buildings. Such methods are common in our large cities, where, due to the height of the buildings, it is necessary to install pumps with tanks located on the roof or in the upper portions of the buildings. In such cases, a comparatively small pump takes water from the street mains, and, operating continuously, or nearly so, feeds the tank on the roof. The fluctuations in demand by the occupants of the building are supplied from the tank. Under such conditions, the maximum demand made by a given building may be, and usually will be, smaller than where no pumping system, with its accompanying tanks, is found.

Another difficulty in using the size of meter or size of service pipe as a positive measure of the demand which a customer will make, is due to the fact that the variation in capacity in meters is so great. The smallest meter ordinarily in use is the so-called ½-in. meter, and is used in connection with ½-in. service pipe; the next larger size is the ¾-in. meter, used in connection with the

¾-in. service pipe. The ¾-in. meter has just twice the capacity of the ½-in. meter. The 1-in. meter has four times the capacity of the ½-in. meter; the 1½-in. meter, six times; the 2-in. meter, ten times; the 3-in. meter, eighteen times; the 4-in. meter, thirty-six times; and the 6-in. meter, sixty times the capacity of the ½-in. meter. Where the larger meters are required, the discrepancy, it will be noted, is not so great, but the difference between the capacity of the ½-in. meter and the ¾-in. meter is so great proportionately as to tend toward injustice if the capacity of these smaller meters is taken as a direct and definite measurement of the demand. For the purposes, however, of this discussion, and in order to obtain a basis for calculating the demand, I have adopted the term " demand unit," using the rated capacity of a ½-in. meter as one demand unit. The rated capacity in demand units of each size of meter is shown by the following Table 2.

TABLE 2.

COMPUTATION OF " DEMAND UNIT."

Size of meter, inches .	½	¾	1	1½	2	3	4	6
Rated capacity . . .	15	30	60	90	150	270	540	900
* Ratio of capacity . .	1	2	4	6	10	18	36	60

In 1911 there were approximately 1 905 meters, and, based on the above method of calculating the demand, the following Table 3 has been arranged to show the total number of " demand units " as measured by the number of meters then in use by the company.

TABLE 3.

Size.	Number.	Demand Unit.	Total Demand Unit.
½	1 617	1	1 617
¾	209	2	418
1	48	4	192
1½	20	6	120
2	10	10	100
3	0	18	0
4	0	36	0
6	1	60	60
	1 905		2 507

* Using rated capacity of ½-in. meter as the " unit of demand," the " demand unit " value for each size of meter is shown in line.

If the computations in Table 1 are on a correct basis, each customer found on the books of the company should pay $2.22 per annum. Each customer with a ½-in. meter should pay $12.06; each customer with a ¾-in. meter will pay $24.12, and the amount which each customer will pay for the second class of expenses will be as shown in Table 4, the amount paid to be determined by the size of the meter used in measuring the water supplied.

TABLE 4.

Size of Meter. Inches.	Amount to be Paid.
½	$12.06
¾	24.12
1	48.24
1½	72.36
2	120.60
3	217.08
4	434.16
6	723.60

For the two payments already made, the customer would receive no water. These first two charges are to cover (1) costs of billing, meter reading, accounting, etc.; (2) maintenance costs, including interest and depreciation upon the quota of plant and mains installed and kept at all times in readiness to supply the respective water-takers. A study of Table 1 will make this clear. Water used, that is, the pumping cost of water used, would be charged for in addition, at the rate of 7.2c per thousand gallons. Such a method of charging would probably result in a more equitable distribution of the costs over the customers who cause them.

Systems of rates, however, made up on this plan are frequently misunderstood by the great majority of small customers, and for that reason, rate experts have been reluctant in recommending their use. It should be noted, however, that there is a growing tendency on the part of both privately operated utilities and those operated by municipalities, to arrange the rate schedules so as to more equitably distribute the costs.

The City of London recently adopted a schedule of rates based on the principles explained above, in connection with its electric lighting service. A large number of electric lighting companies,

and a somewhat smaller number of gas companies, in this country sell their product in accordance with a schedule made up in line with the methods referred to above. I do not know of any water-service schedules made up in the form which I have explained above.

I discussed this matter a few days ago with Mr. Cuddeback, another member of our committee, and he asked me flatly if I would try to impose such a schedule on any of the companies in New Jersey, and in answer I read to him an extract from a report on this matter which I made to the New Jersey Commission more than two years ago.

"In a situation such as existed in the town referred to, which was a seashore resort, where the method of computing minimum charges had already led to a feeling on the part of many customers that a minimum charge is not justified under any circumstances, it appeared that the public would not perhaps sufficiently appreciate the complexities of such a rate schedule as to warrant an introduction of a schedule rigidly based on the principles explained above. Nevertheless, the considerations adduced above led to the conclusion that there ought to be a minimum charge graduated with reference to size of meter and size of service used in connection with each customer."

MR. MORRIS KNOWLES * (*by letter*). The committee deserves much credit for calling attention to the fundamental factors which should govern the making of rate schedules. We may expect in the near future that there may be a substantial agreement on many of the perplexing problems affecting the fair value and a fair gross return for a public utility. It is necessary to remember, however, that such determination is a preliminary step, only, to the distribution of expense among all the rate payers, by just and equitable charges.

Owing to the difficulty of recognizing inequalities in rate schedules, there has not been so much study given to this portion of the general problem of valuation and rate making. And yet all who give the matter thought must recognize it as one of the most important and complex portions of that problem.

Our attention has been called to the old-time slide in rate

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schedules (frequently saw-tooth in construction), and more often a relic of some past copying from a schedule elsewhere in use and without any consideration of the propriety of application in a given case. It is important that we should understand that with a proper service charge (and the writer heartily agrees that this is the correct method of establishing a rate for the " Stand-Ready Service ") then there is no particular advantage in the slide and there may be some positive disadvantages.

The writer would go further than the committee and suggest that in most cases there is no need of an intermediate rate but that there be two only; one, the standard general rate per unit of measurement, and another so low, if necessary, that the actual active costs of service only are met. The latter figure the writer chooses to call the " out-of-pocket cost," viz., that figure which if service were given at any less there would be a direct monetary loss because of not meeting actual operating expenses in proportion to quantity supplied.

It is this low rate, or " out-of-pocket cost," which the writer would particularly like to emphasize and to show the fallacy of the ofttime repeated assertion that such low rates constitute discrimination. He would also suggest that there are several reasons, in addition to those stated at the last paragraph on page 202 * et seq. for the use of a low charge in a sliding scale of equitable rates, and further that such smallest takers "*may even be profitable* to the system at low rates."

First, we may ask ourselves what are equitable rates, and, assuming that we have disposed of the question of fair value and reasonable return, we may define:

" Equitable rates are such as will assess the proper gross income upon consumers without discrimination, and with due regard for the public interest."

" Discrimination " is defined " differential treatment," and the literal application would seem to require that rates " without discrimination " should be based strictly on cost of service, without differential treatment according to amount of use, hours of use, kind of use, or any other distinction. It has been repeatedly

* JOURNAL N. E. W. W. A., Vol. 28 (1914).

decided, however, that this term does not preclude the classification of consumers and differential treatment of the classes, on any reasonable basis. Some extension must therefore be given to the literal meaning of the term, in order to make it workable, and while it has not been clearly formulated by the authorities, the " rule of reason " would appear to require that discrimination be defined as " differential treatment, except in so far as public interest requires."

Pursuing this line of thought a step further, we may come to the conclusion that there are but two grounds on which " public interest " may require differential treatment of consumers:

First, in order to secure some contribution to the public welfare — a method of indirect taxation of those against whom the differential treatment militates.

Second, in order to lower the cost to other consumers by retaining or securing custom which would otherwise be lost.

Some will no doubt contend that " with due regard for the public interest " has reference to the general welfare in such a way as to justify the lowering of rates on certain necessities to certain consumers, even to below cost, for the sake of extending the benefit connected with their use, or in order to encourage business, or for some similar reason. The argument appears to be that, while such steps have the effect of saddling a disproportionate share of the expense upon other services, or upon other consumers, it is nevertheless justifiable as a kind of indirect tax, and as in the public interest.

The writer sees no force in these arguments as applied to rate making. Indirect taxation is a useful part of our system of raising governmental revenue, but it should not take the place of actual governmental appropriation as a method of subsidizing any industry or service, no matter how desirable the encouragement of the latter is from the point of view of public welfare.

There remains, then, only the second basis as a proper reason for differential treatment of consumers — in order to lower the cost to other consumers by retaining custom which would otherwise be lost. How this works out may be very readily explained. Assume a small water works with a gross income of $35 000, which must be collected when it is supplying 1 000 000 gal. per day.

Now suppose one larger consumer, using 100 000 gal. per day and paying $3 500 per year, should find that he could secure water elsewhere at a cost of $2 500 per year, and should disconnect from the mains. The amount supplied would drop to 900 000 gal. per day; but interest, depreciation, and maintenance would remain practically the same; it would still be necessary to have the same number of engineers and firemen; and the only saving would be the small amount on fuel, coagulant, oil and waste, etc., which would certainly not be in excess of one thousand dollars per year, and would probably be a great deal less. So that the gross income to be raised might be reduced to say $34 000, all of which would have to be raised from other consumers. Now, if other conditions remained the same, and the rate for the large consumer were reduced so as to just hold his custom, when paying $2 500 per year, the total gross income would still be $35 000, and the portion to be raised from consumers other than the large one would be $32 500, or $1 500 less than in other cases. Their rates could, of course, be correspondingly lower than would be necessary if the large consumer were lost. The advantage of such an arrangement to the consumers is obvious, and such differential treatment, if necessary to secure this advantage, would not only constitute discrimination, as has been defined, but would appear to be a plain duty of the water works as a public utility.

In brief, it is to the advantage of all consumers that large, long-hour, high load-factor consumers be retained. Differential treatment of them does not constitute discrimination, so long as it will result in advantage and saving to other consumers. Such concessions in rates, however, must not be greater than actually necessary to meet the competition of other sources of supply. And, in any case, they must not be so great as to increase instead of decrease the income to be collected from other consumers. Thus in the case cited above, if it were possible to get the business at $2 500, any rate less than that sum would constitute discrimination. While if it were really necessary in order to meet competition, any rate greater than $1 000 per year would effect some saving for other consumers, and would be justifiable. A rate less than $1 000, however, would make the amount to be collected from other consumers greater than if the large consumer ceased entirely

to take service. This would certainly be discrimination under our definition.

The lower limit ($1 000 in the above case) below which rate concessions cannot be made, even if necessary to secure business, without constituting discrimination, and which represents the actual expense which would be saved if the consumer in question were disconnected, the writer calls the "out-of-pocket-cost," and its distribution over the quantity used by such consumer produces the rate to charge per unit of measurement. It has been found not only useful for fixing the lower limit of the proper total annual charge, but also in framing rate schedules.

As an illustration of how such lowered rate may be determined, the following may be of help. The cost of supplying water may be said to be made up, in the first analysis, of the "cost-of-readiness-to-serve," or costs which result from providing the plant and standing ready to serve and which are wholly independent of the amount of water supplied; and "output costs," which result from operating the plant, and which vary more or less closely with the amount of water supplied.

The "cost-of-readiness-to-serve" may be further subdivided into "capacity-cost," of which interest is the best example, which varies directly as the capacity of the plant, and may equitably be distributed to consumers in proportion to their demands, which together require this capacity; and the "service-cost," which varies with the number of services, and may equitably be assessed equally upon all services. Meter reading, billing and collecting are typical of this.

Similarly, the "output-cost" may be divided into two parts, the "out-of-pocket-cost," defined as above, and including all expenses for materials and labor used in small units and varying closely with the consumption, such as coal and alum; and the "remaining-output-cost," which includes expenses occurring in large units and varying somewhat with, but not directly as the consumption. Typical of these are the wages of pumping engineers and firemen.

In computing a rate schedule, it seems reasonable to divide the gross income into these four parts. The first two included in "cost-of-readiness-to-serve," the committee has properly placed

in the "service-charge." If no differential treatment were necessary, all the remaining costs would then be assessed by a uniform meter rate, obtained by dividing the total "output-cost" by the total annual metered sale of water. Differential treatment, in order to secure the business of favorable consumers who would not take water under these circumstances, might then be effected by relieving such consumers either of a portion or all of the "service-charge," or of a portion or all of the "remaining-output-cost," or of a portion or all of both. But it happens that the "service-charge," so calculated, is ordinarily a small part of the cost of water to the large, long-hour, high-load-factor consumer, to whom concessions must be made. Moreover, it would unduly complicate rate schedule computations to attempt to divide the necessary concession between the "service-charge" and the "meter-charge," and the writer has not, in his experience, met with any such case in which the possible concession in the meter rate was not sufficient or more than sufficient to get the business.

Conceivably it might be possible to classify consumers into groups by quantity used, location, or whatever reasonable basis made differential treatment necessary, determining for each group the cost of an alternative supply to which they would turn if concession were not made, and fixing in this way the extent to which it would be necessary and proper to relieve each group of a portion of the charge. But ordinarily this would be difficult or impossible and unnecessary, and it will usually be preferable to group all such large consumers, whose loss is threatened, into one classification, determining the extent to which it will be necessary to relieve the consumer most favorably situated with respect to an alternative supply, and either apply his rate to all large consumers, or, if he is very large, then apply a midway rate to others somewhat smaller in capacity.

Such computations cannot, of course, be established as theoretically precise, but improved accounting and good judgment will lead to results in which confidence may be placed as closely approximating the ideal.

There is one more thought which the writer would like to bring for consideration as a practical human factor, and that is that the "service-charge," or "minimum-charge" as it sometimes is

called, for the $\frac{5}{8}$-in. meters should include the cost of 2 500 gal. per month, or some such reasonable amount. This will not place out of balance the apparent uniformity of increase in "service-charge," and will forestall any possible criticism that metering will cause the small householder to be unduly frugal and that the use of water by the poor might be curtailed to a point below the minimum requirements of hygiene.

MR. COGGESHALL. Mr. Chairman, I want to say in corroboration of Mr. Lockridge's statement about the municipal buildings that we have been fortunate in the last five years in having meters installed. In our city, now, every service is a metered service.

All the public buildings and all the public supplies except fire hydrants and sprinkler supplies are metered, and each department pays from its own fund just the same price — 15 cents a thousand gallons — as every other taker does in the city, with the exception of manufacturers; they have a rate of 10 cents a thousand gallons. One schoolhouse, formerly using — or mostly wasting — $3 500 worth of water per year, when no charge was made, now uses about $200 worth.

MR. CHARLES W. SHERMAN. There is one point in the committee's report which I am inclined to wish had been expressed a little differently. That is, in the item about obtaining the service charge, "An amount which will represent the approximate average value to the works of the water that passes a domestic meter without being registered."

This portion of the "service-charge," — as I look at the problem, — what this third part of the service charge should cover is the cost to the system of the water unaccounted for, and the unaccounted-for water isn't by any means all going through the meters without being registered. I admit, of course, that a part of it is; and it may be that the result arrived at by the committee is substantially what would be reached in the way it would occur to me. But, nevertheless, the fact remains that the leakage from the main pipes and any other unaccounted for water represents a cost to the works which must be divided among the water takers, and which ought to go into making up this particular part of the service charge.

The matter comes home to me especially from our experience

in Belmont during the past year. We have succeeded in reducing the unaccounted-for water from approximately 33 per cent. to about 28 per cent. in the course of one year, and as far as we know that reduction is substantially all in small leaks in the main pipes. It means, of course, a great deal of careful work on the part of the superintendent, and unceasing vigilance in finding and stopping the small leaks. But there is no reason to believe that the saving is due in any appreciable measure to greater accuracy in the metering of the house supplies. For those who do not know, I will say that it is a 100 per cent. metered town, and that the water is metered to the town by Venturi meter; all of the water used is carefully accounted for. There is practically no street watering at the present time, on account of oiling the streets. The water used for sewer flushing is metered; when the gang goes round to flush the sewers, the water department puts a large meter on the hose with which they do the flushing; and the amount of water which has to be estimated is hardly more than that lost by filling new pipes and flushing dead ends.

Of course the above percentage accounted for is nothing to boast of. I quote the figures merely as an indication of the importance of main pipe leakage as compared with water passing house meters without registering.

MR. D. A. HEFFERNAN.* Mr. Sherman has spoken about the consumption of water in Belmont. I do not want to let this opportunity go by without telling the conditions in the town of Milton. The town of Milton is one hundred per cent. metered. During the year 1914, the water measured —

By Venturi meter was	103 549 000 gal.
By Metropolitan Avenue meters	17 410 359 gal.
Total	120 959 359 gal.
Registration of house meters	101 516 690 gal.
Unaccounted for, or waste	19 442 669 gal., or 16 per cent.
The average daily consumption is	331 396 gal.
Gallons per day to each inhabitant	38.6
Gallons per day to each consumer	41
Gallons per day to each family	183
Gallons per day to each tap	188

* Superintendent Water Works, Milton, Mass.

We have about fifty miles of cast-iron mains.

MR. R. D. CHASE. I would like to submit a table of the results in Fall River. It is divided into the various items, and then at the end the amount unaccounted for, which runs in various years from about 14 to 16 per cent.

PER CAPITA CONSUMPTION FOR VARIOUS PURPOSES, 1914.

Purpose.	Gallons per Capita.	Per Cent. of Total.
Sold — Manufacturing purposes	6.46	13.20
Sold — Domestic purposes	21.48	44.00
Schoolhouses	2.02	4.14
Public buildings	1.37	2.81
Parks and cemeteries	1.19	2.44
Street watering	2.74	5.65
Flushing sewers	.46	.94
Puddling trenches	.32	.65
Fires	.53	1.09
Maintenance Water Department	4.12	8.45
Overflow waste — back to lake	.70	1.43
Unaccounted for	7.41	15.20
Total	48.80	

Based on population, May 1, 1914, 122 231.

Year.	Daily Average Consumption. (M. G. P. D.)	Daily Average per Capita. (Gals.)	Amount. Gals.	Sold per Capita. Per Cent. of to Total.	Amount Unaccounted For, per Capita.	
					Gals.	Per Cent. of to Total.
1905	4.40	41.34	24.65	59.75	6.46	15.65
1906	4.47	41.49	24.79	59.80	6.02	14.62
1907	4.94	43.93	25.79	58.75	7.56	17.25
1908	4.96	43.48	27.25	62.80	6.26	14.44
1909	5.34	46.40	25.00	59.00	5.84	12.60
1910	5.20	43.59	25.90	59.40	5.04	11.55
1911	5.17	44.09	26.30	59.75	6.24	14.15
1912	5.33	46.23	28.19	61.00	4.97	11.78
1913	5.63	47.04	28.10	59.70	5.62	11.94
1914	5.96	48.80	27.95	57.25	7.41	15.20

MR. W. C. TANNATT, JR. Mr. Chairman, there do not seem to be many friends of the flat rate, but after hearing the discussion

by Mr. Morris Knowles I cannot help thinking of the experience of Easthampton. We went after the big business, and allowed a rate where we felt we were making the cost of production. The big business found that it was such an item to them that in a few years that class of construction grew so that the system had to be enlarged. The enlargement practically equaled the cost of the former system, and when we attempted to charge the big consumers at the mills a fair proportion of the cost of the enlargement we lost the business. I can see where a system that has been figured with a large factor of safety can very well go at the big consumer with a small rate, but if the system is figured anywhere near up to the capacity of the town, it is a question to me whether they have a right to do it, whether it will be policy.

MR. CHARLES N. TAYLOR.* The minimum rate in Wellesley is $6 for 16 000 gal. of water, or 37½ cents per thousand gallons. Any water that is sold or used beyond this amount is sold at the rate of 25 cents a thousand gallons, whether they use one thousand or one hundred thousand gallons. To my knowledge the town has lost only one customer by the rate being too high, but that was a very good customer. If the town had that customer to-day it would be receiving more than $10 000 a year additional revenue.

The point which interests me most in this discussion has not been touched upon, and that is the charge for water to summer residents in localities that are occupied only about four months in the year. If water is metered to the summer takers, unless there is a minimum price, there is not sufficient revenue to pay the interest on the investment. How should water be charged for in such cases? The cost of laying the pipe to the summer cottages is just the same as it is to the permanent residences, and pressure has to be maintained in the pipes the year round in order to give the cottages fire protection. The investment on the pumping machinery and the standpipe and everything is just the same in both cases. But if you undertake to charge the summer people the same price for the use of the water for a few months that you charge for a year you are called a robber and told that it is not fair.

MR. HEFFERNAN. In the town of Milton we have a minimum charge of $12 per year, and if people go away in the summer and

* Contracting Engineer, Wellesley, Mass.

have the water shut off in the street, a rebate is made, providing the water is shut off for four months, the minimum charge being pro rata from the time the water was turned on.

MR. TANNATT. Mr. Chairman, that would do very well when only a few go away, but where more than two thirds of the people are summer visitors, it would reduce the revenue to almost nothing.

MR. HENRY A. SYMONDS.* Mr. Chairman, I would like to call the Association's attention to a bill before the legislature at this time which deals with this particular subject. It says:

"All corporations and companies engaged in the distribution and sale of water in this commonwealth and occupying the public streets with their mains and pipes for that purpose shall not, where water is supplied for domestic service to a consumer for any period of six months or less in any year, charge such consumer a sum greater than one half its annual minimum rate for like services."

I think that while this speaks purely of corporations and companies, there are represented in this Association a large number of water companies. Whether this particular policy is advisable for both public and private water works, I think should be looked at from the standpoint that what is fair in one case is apt to be fair in the other.

In regard to the question which Mr. Taylor asked, the establishing of rates in shore places has come to my attention a number of times, where there was purely a summer population and where the income during the winter months was almost nothing. The way we have solved it, or tried to solve it, has simply been by charging the yearly rate for those places. That has in general been satisfactory after the matter was thoroughly understood. Of course, as has been pointed out, the full investment must be made in order to take care of that service, whether it is for three months or whether it is for twelve months. About all the difference it makes to a company or to a town when they supply a section of that character is the little extra fuel required for pumping during the remaining period. The same organization practically has to be maintained right through the whole year. In a shore place every one who comes there for three months is in-

* Boston, Mass.

creasing what is the maximum capacity of the plant or the demands on the plant, and it seemed to us that while there is a certain point of view where it is a fair proposition, from the company's or the town's point of view it is hard to see how to get round that proposition except by a yearly charge.

MR. CUDDEBACK.* It seems to me that the rates suggested by this committee are particularly applicable to a case of just this kind, where there is a service charge which includes no use for water. That service charge would be applicable to a house whether it is occupied for three months, four months, six months, or a year, and then a charge for the water based on the other expenses. That would of necessity mean a meter rate. And then there should be a charge for removing and resetting the meter to take care of that expense.

MR. HAZEN. Some of the members think that the same rate ought to be paid by everybody, and by the schedules that they have drawn some members seem to think that there ought to be fifty points of slide; and all points of view between have been expressed, either in the discussion or in the schedules. The committee thought that a compromise perhaps of a scale with three slides was the best to adopt at this time, and it would be understood that those who do not want the slide are at perfect liberty to make the three rates the same, in which case the slide disappears and they have the full rate. That is fully provided for in the schedule. But on the other hand the committee does believe that there is oftentimes a legitimate difference, an actual difference, that cannot be overlooked, between the conditions of service to small consumers and to large consumers, and that the sliding scale has an inherent reason for existing and it cannot be altogether pushed out of the business at this time.

The great majority of consumers come under the domestic rate in the proposed schedule. I have just been through the records of a smaller plant with about 5 000 services, and in them I find that instead of the 92 per cent. that Mr. Lockridge finds in Springfield, fully 97 per cent. of all the services would come under the domestic rate, and of the rest more than 2 per cent. would come under the intermediate, and only a small part of 1 per cent. under

*Engineer and Superintendent, Passaic Water Company, Paterson, N. J.

the manufacturing. But notwithstanding that, the 20 services under the manufacturing rate take 35 per cent. of the water, and so what you are going to do with these few services is a very important condition.

In regard to Mr. Sherman's question I would say that the committee did not take the matter up from the standpoint that he suggested, but they did take it up from the standpoint which they stated. The question of the unaccounted water in the system was not taken up by the committee in any way. It is a perfectly proper matter to take up, and the committee probably would have taken it up if they had had more time and more statistics, but they did not get to it.

Mr. Knowles' and Mr. Betts' discussions run along something the same lines. I am particularly struck by Mr. Knowles' expression for this less-than-cost kind of services which he thinks water-works plants ought to adopt at some time, and I am interested to note the peculiarly expressive phrase which he used to express it. He called it the "out-of-pocket" charge. Now, it is the first time that I ever heard of any one who wanted to get "out-of-pocket" business. As far as I know, we are all looking for "in-pocket" business. I think the expression is an apt one, but if it were applied to the company which Mr. Betts gives some statistics of in New Jersey, and if that company — which I think I know something about, if I am not mistaken in his discussion of it — could develop a large thriving business at the rates he suggests, I do not think anything could happen to put them into bankruptcy quicker. Nevertheless, it is an interesting theoretical discussion. It goes to show that all sides of the question have to be considered. When a plant is over-built and wants business, it is in one condition, and consideration of those conditions alone would result in one schedule of rates. When it has grown pretty nearly up to capacity and needs to be extended, the conditions are different, and consideration of what is happening then would lead to an entirely different scheme of rates.

Now, it is my feeling that a water rate, to be a fair rate and a good rate, ought not to apply to either of those extreme conditions; it ought to be a rate that will work year in and year out and at which the business can be done and expenses met, and — in the

case of companies, at least — a reasonable profit earned. With that in view I do not think that we need to go very far on the out-of-pocket rate growth.

There is one matter which I should like to speak of, — the question of gallons or cubic feet. I think you can help us on that. There is a very good discussion here which I will read, and then I am going to ask the chairman if he won't take an informal vote of the members of the Association present as to their preference between gallons and cubic feet. And after that it is my thought — after this meeting is perfected — that your committee will try to digest another meeting and will make a final report of the schedule which they will recommend to the Association for adoption, and which I hope will be in shape so that you can adopt it and that it will aid in bringing order into this complicated matter.

This discussion which I am asked to read is from Mr. Schwabe. *

I am convinced from experience that gallons in dealing with the consumer is the better unit to use. I find it much easier to talk with a consumer on his water consumption in gallons than in cubic feet, and find the customers have greater confidence in meters and in our statements, as they can readily check up their meter readings and make tests themselves.

The public buys all liquid commodities by the gallon unit, which is a point in favor of supplying water on the gallon unit. Pumps, standpipes, etc., are all rated on gallon capacity, and I firmly believe that the gallon should be commonly used as a unit for the sale of water, as it is the standard unit for liquid measurement, while a cubic foot is a unit of volume measurement irrespective of what the consistency of the volume is.

The argument that other commodities, such as gas and electricity, are measured in units that are foreign and not understood by the layman is no excuse for using such a unit for the measurement of water when there is a better and commonly understood unit that can be used.

If there is no objection, Mr. Chairman, I think it would be well to ask a rising vote on the preference of the men present as between gallons and cubic feet.

THE CHAIRMAN. Mr. Hazen has requested that the gentlemen

* President and General Manager of the Thompsonville Water Company.

express their feeling as to whether the meter should have dials reading in cubic feet or in gallons. All those in favor of cubic feet will please rise. [Seventeen members rose.] All those in favor of gallons please rise. [Twenty-three members rose.]

It seems that most of the members are in favor of measurement by gallons.

Mr. Walter P. Schwabe. Mr. Chairman, I was not sure that I was going to be here, and that is the reason I wrote that letter about the gallons and cubic feet.

I want to say that in Thompsonville we are just going over to the meter system of charging, and it might be of some value for you to know that we will not bill less than tenths of a thousand gallons; in other words, not less than a hundred gallons.

The meters are equipped with a straight reading register; the zero on the register plate and the figures on the wheel indicating tens are in red, the balance in black. Meter readers will read the black figures only. These figures will be used for billing, so many thousands and hundred gallons. The dials with red figures are only necessary for test.

Mr. Francis W. Dean. Mr. Chairman, in regard to this vote, while the result is interesting, it seems to me that there are so few members here that the vote really does not mean much. Now, while I think it would be well to find out what the members of the Association think, I feel that a vote should be taken when there are more people here, or else a letter ballot be obtained.

As for me, I think that the users of water know enough about feet to know what a cubic foot means. That quantity of water ought to be pictured on the imagination of a person just as thoroughly as a gallon. I think more accurately so.

Mr. F. N. Connet.* Mr. Chairman, twenty years ago about 90 per cent. of the orders for Venturi meters specified "cubic feet" graduations for the counter dials, but to-day about 95 per cent. specify "gallons" instead. I am referring to meters for municipal water works only, because "cubic feet" are universally used for large meters for water supplied to turbines and for irrigation purposes.

The Chairman. I take it that this is an informal vote, a sort

* Chief Engineer, Builders Iron Foundry.

of index for the committee. I may say that I have seen at times mild amazement on a consumer's face when objecting to paying 15 cents per hundred cubic feet. He cannot seem to understand or grasp what a hundred cubic feet is, and mentally he tries to figure it out. At times the cubic foot would appear as foreign to him as a cubic centimeter, but when the consumer was told that a hundred cubic feet was equivalent to 750 gal., he certainly looked amazed and relieved. The ordinary water taker who keeps tabs on his water bill does not understand the unit cubic foot or have any conception of its equivalent in gallons.

Mr. Caleb M. Saville. The results of the studies of this committee are a most valuable addition to the literature of water-works operation, and this Association is to be congratulated in having members of such high professional standing who are willing to give of their time and experience for the preparation of such an important subject.

In spite of the fact that I seconded the move to accept this report at the last meeting of this Association, I am very glad that final action was postponed. On more careful consideration of its provision, it seems to me that the report does not fully recognize some conditions which are very important.

Many service connections are made entirely for "ready-to-serve" purposes, and comparatively little water is used.

With the high meter rate and low service charge, this class of consumer is not paying its share of the water department expense. In other words, the constant consumer is paying for the protection of the chance customer.

The arbitrary separation of service charges into three divisions, it seems to me, does not allow that elasticity in making rates which can apply immediately to the small domestic consumer on the one hand and the large manufacturing establishment on the other.

Local conditions vary so greatly that it appears unwise for this Association to go on record as absolutely being in favor of the adoption of any particular rate scale without more information before it as to other scales that might be of advantage under certain circumstances. If it is practicable, I would like to see in the summary of a report reference at least to several variations of assessing meter rates which might be adaptable to local conditions.

I believe that a hard-and-fast standard is not practical of application to the needs of all water departments. For example, it seems to me that the schedule proposed might not apply to a small system when all of the consumers except one are "for domestic purposes" and the exception is a large manufacturing plant which has its own supply for ordinary occasions, but uses its public supply only as an auxiliary to keep down its fire insurance rates.

Such cases are not at all uncommon, and, due to the requirements for fire protection, a large burden is put on the water department without adequate return under the schedule here recommended.

It is recognized that it is almost impossible to draft a schedule that will be of universal application. In its preliminary report the impracticability of strict adherence to the proposed schedule was met by the statement that the schedule proposed was an "ideal one to be worked toward." Personally, I would not like to see this Association accept the recommendation of this committee as *the ideal* without further discussion.

MR. A. E. WALDEN (*by letter*). Would it not be better, before a final decision is reached on this subject, to submit tabulated figures as to the water rates obtained from the various companies, together with a rough outline of their systems; that is to say, a brief statement as to whether they are purely gravity supplies or are being pumped either by water or steam, and whether or not all the supplies are filtered, together with pressures carried. It would seem that this would allow the various companies interested to form some conclusions as to what rates were fair as between the various companies and systems.

DISCUSSION AT MEETING OF MARCH, 1916.

MR. CALEB M. SAVILLE. I would like, Mr. President, to move that this matter be postponed for further discussion, or be postponed before being finally accepted, until the first fall meeting; and that the committee be asked if they will submit such other methods of assessing rates as they had under consideration when they proposed this one.

The President. You have heard Mr. Saville's motion.

A Member. Second the motion.

The President. It is now open for discussion.

Mr. H. V. Macksey.* Mr. President, if you were confining the discussion strictly to the motion before the house, I should oppose the motion; because as it was put, it seems to me to defeat the main object of bringing this question up to-day; it was cutting off discussion by the members. It appears that what has been going on — a free discussion of the report of the committee — should be encouraged; and after that it is proper to hand the report back to the committee and let it consider our view of its action and possibly it may then decide to modify the report.

I take it for granted that, because all the members of the committee signed the report and there is no minority report, all the members are in favor of it. I think we must assume that, on the facts before us. And while I do not agree entirely with the report of the committee and feel that the gentleman from Holyoke has the right idea, — that we should sell metered water at a flat rate, — I doubt if it is practical at this time to do so in all cities as is done in Holyoke. There is a tendency in all cities to encourage the manufacturer by giving water at cost or less than cost, and letting the little fellow pay the freight, but it is something that we should oppose at all times. We should try as far as possible to keep the rate up for the large consumer, and give the same rate to the small consumer.

There is a point that I believe is not touched upon in the report of the committee; that is the fire service, the service for fire protection only. In the majority of cities there is no charge at all for fire service. Water departments and water companies should be willing to help in a great emergency like a fire, and do so without charge, but, if we are attempting to run municipal water works like business institutions and separate from all other municipal activities, they should not be asked to supply the appurtenances for that free service without charge, as is being done in many cities. Some consideration should be given to fire service in this report.

The form in which we are asked to report is excellent. The

* Superintendent Public Works, Woburn, Mass.

ideas which the committee have offered in regard to classifying services and charges therefor are very good. I hope that all the members present will voice their opinions to-day, and that after that the motion before the house will prevail. If the membership gets more information from the committee, and has more time to think it over, perhaps in the fall it may be able to give some assistance to the committee.

Mr. President, may I be allowed one word more. I would like to say, after listening to the last speaker, that I think possibly his view is limited. In the little city that I am connected with at the present time, we have another use for water. I refer to the truck farm, where a farmer asks for a 2-in. service. At times he wants much water, a greater part of the time he wants very little water, and during the winter practically none. We are carrying on that farm business for him, and the little fellow who works on the street is asked to help to pay to carry on the farmer's work.

It is the old view that the water department must help the city as a whole; if it is able to extend a pipe, never mind if it does not bring any revenue to the water department, — think of increase in valuation! But does the water department get any of that increased valuation? No. All that increase in valuation helps the mayor to decrease the tax rate. The water-takers as a class should not be taxed to support the real-estate owners or the manufacturers as a class. We desire a square deal, as they do in Holyoke.

Mr. Edwin C. Brooks.* Mr. President, isn't it a fact that large industries in locating their plants have regard to the labor market more particularly than to the cost of water; and does any manufacturing establishment use any more water than it is obliged to in its business?

Mr. R. C. P. Coggeshall. Mr. President, Mr. Macksey has just raised the question that I was on the point of introducing. Why not consider the introduction of a charge for standing ready to deliver on the sprinkler service, for which there is now no charge? It seems to me that that is a service which ought to be recognized.

The President. Do you ask that question of me? I

* Melrose, Mass.

would say that I find that if manufacturers can obtain water from any other source than the water department they will do so, — if they believe that they can get it more economically that way. That brings up the old question of the protection of the primary water supply from the secondary water supplies. I can say also that I guess the water question would not bother the munition manufacturers of Holyoke or Bridgeport at the present time, if they could get help.

MR. COGGESHALL. Mr. President, perhaps a little résumé of what has happened in New Bedford may in a way answer that question. Previously to 1909 the rate for manufacturing purposes was ridiculously low; viz., $2\frac{1}{2}$ cents per thousand gallons. That rate was influenced by reason of the bequest of Sylvia Ann Howland, the aunt of Hetty Green, who gave the city $100,000, the income of which was to be used in encouraging the introduction of manufacturing. When this bequest was made, the city was small and there was only one corporation of three mills located there. You are all witnesses to the fact that New Bedford has now grown to be one of the largest textile manufacturing centers in the country.

In 1909 we were influenced by the example of Holyoke; all schedule rates of every kind were discontinued and a single rate of fifteen cents per thousand gallons for metered water was substituted for every use. Then came the argument that Sylvia Ann Howland had left that $100 000 to encourage the introduction of manufacturing; and on the strength of that they finally deemed it wise to place the manufacturing rate at ten cents, leaving the fifteen-cent rate for all other purposes. The manufacturers vigorously protested and predicted the decline of New Bedford's prosperity. They declared that the ten-cent rate would prohibit the introduction of additional mills. This has not proved to be true. Many new mills have since been added; there are three now going up. And, mark you, New Bedford is about the only large manufacturing city that does not have a secondary supply of fresh water aside from the city water. Every mill there has got to take every drop of water from the city of New Bedford.

MR. FRANK A. BARBOUR.* Mr. President, in recommitting

* Consulting Engineer, Boston.

this report, I believe it would be well to suggest to the committee that, since its final report will stand as the expression of the present position of this Association in regard to meter rates, it should include more definite statements of the conclusions reached in reference to a "flat rate," and the feasibility of assessing in the ratio of frontage or valuation a part of the cost of the system.

The report as now submitted recommends a sliding scale of three divisions with limited amount of slide — the manufacturing rate to be very seldom less than one half the domestic rate. In the progress report of 1914, a reference was made to the question of a flat rate, but it would seem that this Association, if it desires to lead, should more definitely express its conclusions for or against a flat rate, and without such definite treatment of this phase of the problem, it is doubtful if this Association should put its seal of approval on the report of the committee.

Again it would appear that the question as to the advisability of assessing some portion of the cost on the basis of frontage or valuation so to express the benefits received by property owners, regardless of the actual use of water, has not been as well developed as might be the case. This phase of the subject was carefully considered by the 1905 committee, and should be more definitely negatived or approved in the present study of the problem.

As a general statement, approximately one half the average water-works plant is chargeable to the provision made for fire protection — the benefits from which are perhaps more nearly in the ratio of property values than any other assessable unit, and have little or no relation to the amount of water consumed. The law in Massachusetts in regard to sewers requires that at least one quarter of the cost shall be borne by the town or city on the basis of valuation, and it is difficult to understand the logic of throwing the entire cost on the consumer in the case of water works.

It may be that a flat rate is not generally practicable, but the recommendation of the committee that higher rates may be properly charged in the higher districts to meet the expense of the greater pump lift, is a step too far in the other direction. Where is the line to be drawn, and why not charge more in those districts where the trenches are in rock, than in those where the prevailing

material is earth? Why should elevation be made a greater factor in determining cost than the character of the ground encountered?

The last word of this Association on meter rates will be given great weight throughout this country, and the final report of the present committee should consider and discuss, in the broadest possible manner, all moot questions, and should — so far as practicable — point the way towards the ideal, and this without too great regard for present methods.

MR. CHARLES W. SHERMAN.* Mr. Barbour's suggestion of the value of the water-works system to the entire community, and the portion of the running expenses or the fixed charges, or both, which should be met out of general taxes, is, I believe, well worthy of consideration. But if it is taken up, the committee must also consider, as an offset against it, the value of the exemption from taxes which a municipally owned water department enjoys in every case in this state except Holyoke, if I am not mistaken, and probably throughout the country. We hear very little about the value of this exemption from taxes. In one case in which I had occasion to make approximate figures, a short time ago, I was surprised to find that the value of exemption from taxes was very close to the value of fire protection.

THE PRESIDENT. If this motion prevails, Mr. Sherman's suggestion, and Mr. Barbour's suggestion, and every suggestion, will be written out and forwarded to the committee.

MR. S. H. MACKENZIE.† Mr. President, I agree with the gentleman who has just spoken. I believe that there should be a charge of some kind for fire protection. When the charge is included in the water rates, in many instances, it will place the burden where it does not belong, as many times the largest consumers of water have the least property to protect. Value has been given, and the property benefited should stand the cost in accordance with the benefit derived.

The one-rate idea is certainly fine, and should be our ideal, but there are a great many local conditions which prevent its adoption. There is no doubt that many of the old-time complicated rates

* Of Metcalf & Eddy, Consulting Engineers, Boston.

† Water Works Engineer and Accountant, Southington, Conn.

can be simplified and some form adopted which will make comparison easy and the keeping of records less complicated.

When considering the new meter rates, the service or ready-to-serve charge should be taken into account. The services should be paid for by the property owners, as they are for their exclusive use. The ready-to-serve charge should be the expense less proper deduction for fire protection which is incurred whether water is consumed or not; but at the present time it does not seem practical to put the whole expense under that head, as it places a burden on the small user, so that it seems wiser to include part of the charge in the water rate and in that way divide the balance of the expense in accordance with the water consumed.

Five years ago our department at Southington, Conn., adopted practically the system of rates recommended by your committee, except that the service charge is included in the rate for the first one thousand cubic feet of water.

Our rates are as follows: $\frac{5}{8}$-in. meter, \$0.50 per quarter and increase according to size of meter; ready-to-serve charge, \$1.00 per quarter, included with charge for first 1 000 cu. ft.; first 5 000 cu. ft. at \$1.50 per thousand; next 95 000 cu. ft. at \$0.60 per thousand; all over 95 000 cu. ft. at \$0.40 per thousand.

The above has proven satisfactory, although I believe the low rates are lower than we can afford to furnish the water when we have to increase our supply.

If we adopt the single-rate idea just recommended by our friend from Holyoke, and made it low enough so our factories would feel they could use the water, it would materially reduce our income and would be below what we could furnish our small consumers for, as we have an average of about 145 ft. of main to each service. Selling our surplus water to the factories at the low rates mentioned is a material help to our small consumers. It does not seem to me that the postage-stamp theory applies to water departments. We all pay two cents each for postage stamps, whether we buy one or a thousand, but each stamp has a separate duty to perform. It does not make any difference whether it is on a letter mailed by me or on one of a thousand mailed by a factory: each letter is handled separately and delivered to a different person, and therefore should pay the same for the service;

but, in the case of water, 10 cu. ft. a day is delivered to my house, while a factory takes 2 000 cu. ft. through a pipe of the same length and size as used to carry the 10 cu. ft. It certainly would cost much more to deliver and collect for 2 000 cu. ft. to two hundred consumers than to one.

I certainly appreciate the work the committee has done. The chaos under which meter rates have been struggling is giving place to light. Let us have a little more free discussion before coming to a final report.

MR. MORRIS KNOWLES.* Mr. President, I did not at first think favorably of such a motion to postpone, — meaning as it does postponing until the autumn meeting; and yet I now find myself in this position, that I would like to second that motion and briefly state the reasons.

It is true that any schedule or rule is capable of a number of different applications. The committee has very nicely worked out in detail one thought; it is not the only thought with regard to the making of rate schedules. There are several others which are receiving attention all over the country at the present time. I doubt very much if we realize here in this room how a report of the committee of the New England Water Works Association is taken as "gospel truth" even in other parts of the country remote from New England; and if it should appear that the committee had not presented in its final report the suggestions, the recommendations, the arguments, pro and con, for the various methods, before finally stating the conclusion as to why one method was desirable, it would not and should not carry the kind of weight of which we are especially proud.

Then again, when this report first came out, in September, 1914, discussion was requested; some written communications came in, but for some reasons this has not been printed — it is not before us for our consideration at this time. Is it not a matter for the membership at large to decide, whether such subject should be decided without all the information before us? I speak, of course, with entire respect for the membership of the committee. It is probable, however, that, if this be referred to the committee again, they will not become discouraged and think we are turning down

* Consulting Engineer, Pittsburgh, Pa.

things they have done, but will adopt the suggestion of Mr. Saville and bring to us the arguments pro and con regarding the various kinds of schedules.

I myself would feel very strongly that an amendment of this schedule perhaps might be adopted at this meeting; but it seems to me that even that would be undesirable, as we do not have the information before us that has been suggested in the discussions. There are other things that are being thought of over the country. Therefore I do join in the second to the motion of Mr. Saville; and hope that the matter will go over, with the intent that the discussions may all be brought before us, and that the committee may add to the final report the various considerations and arguments bearing upon the use of different schedules in different places.

MR. J. M. DIVEN.* There can be no question about private fire services being of value, but available only to the few; so why should not those who receive the benefits pay for the service? It does cost the water works something, something for inspection and something for " readiness to serve." The benefits are reduced fire risk and business interruptions from fires and reduced insurance rates. It is good business policy to encourage factories and to give them every reasonable concession; factories help the town and every inhabitant, and they are entitled to lower water rates; but should pay for such a special privilege as a fire service for their sole benefit, for not to make such a charge would be to discriminate against the water takers not having such special protection.

MR. HUGH MCLEAN.† Mr. President, I am in favor of the continuance of this discussion to another meeting. We want to know the views of those present relative to the proposition.

It seems to me that to have three rates is the opinion of this organization, and to go out before the country as the report of this organization is a step in the wrong direction.

I have related before my experience with the three rates, and that I think they work an injustice to the small consumer. We set out, about some eight or nine years ago, to abolish the three rates in Holyoke; and we established one flat, uniform rate. For

* Superintendent Water Works, Troy, N. Y.
† Water Commissioner, Holyoke, Mass.

the men's names that are attached to this report to go out before the country and to say that it is their opinion that three rates is the best, they are turning away from the average thought of equal rights to all, special privilege to none. When we assess the valuations of a city, we do not give the large owner a special rate; he is assessed just the same as the small property owner. Why should the large consumer of water get a special rate of five or six cents a thousand gallons, and the small consumer have to pay all the way from fifteen to twenty cents a thousand gallons? Wherein is that justice? Is it not discrimination? Is it not contrary to the advanced thought of legislatures and government of to-day, — that equal rights and special privileges to none shall prevail? It seems to me that the minds of those present should be expressed on this subject, and that if we are going to recommend something for the consideration of our members throughout the country it ought to be more nearly along lines of equality.

I do not know whether or not this is a unanimous opinion of the gentlemen who have studied this report, or whether there is a division amongst them as to the wisdom of it. But personally I have felt that I would be doing an injustice to myself and to my colleagues in our desire to perfect a rate, if I did not voice my sentiments. In Holyoke we have successfully adopted a one flat rate to all, regardless of whether they use a thousand or a million gallons, and it is working splendidly. Now, wouldn't it be better to take a step in that direction, have only two rates, rather than to be going away from it and to have three? Eventually a cry and a demand will be made that the small user is entitled to water at the same price as the big user, because water departments are established primarily for the benefit of the small users.

I do not want to be classed as radical, but, nevertheless, I feel very strongly on this matter, after going through it as we did in Holyoke. When we had the three rates it was a vexing problem all the time; there was a continual demand for the change of the rates, and our Water Board worked on it for four years, till we abolished the three rates and took two, and then we finally abolished the two and took one. It seems to me that if we recommend this report to the country we are taking a step in the wrong direction.

In regard to the matter of charging the fire department for water, we have a flat rate, I think, of eight dollars a hydrant. We charge every department for all the water they use, and we pay a tax like every other corporation.

If we are going to recommend something, it seems to me that we ought to try to get the best. The United States Government does not have three rates; if you buy postage stamps, whether you buy one or two or a thousand, it is the same price. Why the fallacy of having special privileges and special water rates? We are advanced beyond that. It seems to me that a step in the other direction is the step that we men who meet each other and study those problems should advance.

MR. COGGESHALL. Well, isn't it a fact that this report allows any city to establish a flat rate?

MR. McLEAN. Yes. But the principal recommendation is that of the three rates.

MR. McKENZIE. Mr. President, I would like to ask the gentleman from Holyoke if they have a minimum rate, or any way in which they can take care of the small consumer. Do you have a minimum charge of any kind in Holyoke, or is it a flat rate for the actual water consumed without regard to the quantity?

MR. McLEAN. Yes, we do.

MR. CHARLES W. SHERMAN. It seems to me that there is a great deal in what Mr. McLean has said. If I correctly understood the opinions of the committee at the time the original report was presented, they felt that there is a good deal to be said for the single rate. In my own town that is the practice; we have but one rate for water.

I believe with Mr. McLean that the fewer the classes into which the rates can be divided, the better off we are, as a rule. There may be, and doubtless are, places where for reasons of policy, or for other reasons with which local conditions may have more or less to do, it is not wise at present to come to a single rate, and possibly not to two rates.

If the committee's report should be adopted, it would be a step in advance, in reducing the number of classes — which may be as many as eight or ten in some cases now — to three, which of course would be a material gain; and any communities or water com-

panies which found it possible to make the number of classes two, or even one, would be so much the better off.

Mr. Patrick Gear.* Mr. President, in answer to the gentleman who asked if we had the minimum rate in Holyoke, I will say that we do have for tenement blocks. If you are fortunate enough to own a block, with four or more tenements, we will gladly put you in a meter for the sum of five dollars. We allow for said amount eighty-two thousand gallons of water a year per family. The only minimum rate we have is for tenement blocks. The manufacturers and others pay for the quantity of water used.

In some of the mills where pumps are in use, we have set meters, and the quantity of water used by them does not pay our department one dollar; they want a meter in case their pump should give out so that they may be able to get city water. The meter is put in and we get the rental charge on same. I am in favor of that part of the report which says for that kind of a service we should receive some return besides the rental charge on meter.

Yesterday up in Holyoke there came to my notice a case in which a man had a 3-in. meter set in his building and very little water being used; the rental for this meter was $16.00 per year and the quantity of water passing through this meter for last year, the year before, amounted to about $12.00. This man kicked on the rental charge and asked for a smaller meter. The tenant on the top floor of this building where the meter was set used an elevator, run by water, to carry up his goods. After the smaller meter was put in, the tenant lost so much time by the slowness of the elevator in carrying up his goods, he was obliged to move out and by so doing the consumer gained $2.00 and lost a good tenant.

Our people in Holyoke think that we have the finest meter and water system in the world, and anybody that does not agree with us has not the right idea.

Everybody knows that it is the small workingman who is paying for the water, and he is the one that is supporting it. The big fellow will use driven wells if possible. At one time we sold water for three cents per one thousand gallons, and we are now selling if for five cents, and yet they are putting in wells where possible. We sell water as cheap as you will find anywhere, and yet the

* Superintendent Water Works, Holyoke, Mass.

manufacturers are not coming to our city as in former years. They will tell you that the large consumer is the most desirable tenant, but I say that the smaller one is just as desirable, because we have more of them and therefore all should be treated alike and given a flat rate.

PROCEEDINGS.

Executive Committee.

Meeting of the Executive Committee of the New England Water Works Association at headquarters, Tremont Temple, Tuesday, August 8, 1916, at 10.30 A.M.

Present: President William F. Sullivan, and members Caleb M. Saville, Samuel E. Killam, D. A. Heffernan, Edward C. Sherman, Lewis M. Bancroft, Willard Kent, Albert S. Glover, and William S. Johnson, the two latter being present by invitation.

It was voted, on motion of Mr. Bancroft, seconded by Mr. Saville, that additional room at headquarters be secured for our Association at an expense not to exceed $150 (one hundred and fifty dollars) per annum.

It was voted that the President be authorized to appoint a committee to act with a similar committee of the Boston Society of Civil Engineers to consider the matter of a division of the additional office room space; as this committee, President Sullivan appointed Edward C. Sherman, chairman; Samuel E. Killam, Albert S. Glover, D. A. Heffernan, and Willard Kent.

It was voted that the expense of the chairman of the Committee on Service Pipe Investigation recently incurred in traveling be reimbursed him by the Association.

The Secretary read a letter from Mr. F. H. Newell, chairman of a special committee of the American Society of Civil Engineers appointed to consider the expediency of establishing "A National Water Law," and asking the consideration of our Association to the matter and the appointment by us of a similar committee to coöperate with said committee of the American Society of Civil Engineers. After due consideration of the matter, it was voted: That a committee of three members be appointed from our Association on this matter; and the President named as said committee Messrs. Caleb M. Saville, Alfred D. Flinn, and Carleton E. Davis.

Adjourned.

Willard Kent, *Secretary.*

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1916.

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THE ASSOCIATION was organized in Boston, Mass., on June 21, 1882, with the object of providing its members with means of social intercourse and for the exchange of knowledge pertaining to the construction and management of water works. From an original membership of only TWENTY-SEVEN, its growth has prospered until now it includes the names of over **1,000** men. Its membership is divided into two principal classes, viz.: MEMBERS and ASSOCIATES. Members are divided into two classes, viz.: RESIDENT and NON-RESIDENT, — the former comprising those residing within the limits of New England, while the latter class includes those residing elsewhere. The INITIATION fee for the former class is FIVE dollars; for the latter, THREE dollars. The annual dues for both classes of Active membership are THREE dollars. Associate membership is open to firms or agents of firms engaged in dealing in water-works supplies. The initiation fee for Associate membership is TEN dollars, and the annual dues FIFTEEN dollars. This Association has six regular meetings each year, all of which, except the annual convention in September, are held in Boston.

New England Water Works Association.
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This Association, as a body, is not responsible for the statements or opinions of any of its members.

AN EMERGENCY GANG IN A WATER SERVICE.

BY GEORGE H. FINNERAN, GENERAL FOREMAN, WATER SERVICE, BOSTON, MASS.

[*Read September 14, 1916.*]

Failure of a pipe carrying water under pressure always spells trouble to the water-works man, the extent of which varies according to the size, location, and importance of the pipe.

Until the advent of subways, underground wires, improved sewerage, pneumatic tubes, buildings two and three basements deep, and rapidly moving and heavily loaded vehicles, failures occurred occasionally, but usually were due to defective material, water ram, or frost. In the city of to-day, however, with its activity under and over ground, leaks and breaks are frequent, the causes varied, and the consequences more or less serious. The prime factor in the cause of almost all failures is disturbance. Disturbance of a pipe or the surrounding earth is certain to result sooner or later in a leak or break. If the disturbance is quick or violent and of the nature of a shock, the effect is immediate. If it is slow, insidious, and progressive, the effect will develop in time; but, in either case, the time, the place, or the extent of the break cannot be foretold, hence preparation is necessary to meet adequately the situation when it arises.

The first steps towards properly caring for a leak or break is promptly to stop the flow of water. This requires the presence of men with wrenches or valve keys at the location of the trouble, and to get these men on the ground with as little delay as possible it is desirable to transport them in a rapidly moving vehicle. The

automobile meets that requirement better than anything we know of at present. It is therefore obvious that to be prepared to control a break in a water pipe, whether it is large or small, a special force, consisting of men, tools, and an automobile, is a necessary complement to the distribution system of every large water works. Such a force is commonly called an "emergency gang."

The men in an emergency gang should be selected carefully for certain qualifications that an emergency man should possess. He should first of all be a practical man, one who has worked up from the bottom and actually performed the different kinds of work necessary in the laying and maintaining of water pipes and fixtures. He should have a knowledge of the location of the various lines that traverse the city, a knowledge as to their general location, the route which they take, and a knowledge as to their particular location, the part of the street in which they lie. He should know the connections with these lines, the relative importance of the lines and their connections, and above all he should know the locations of the gates controlling the lines and connections. He should be able to make quick or temporary repairs. He should be strong, of good health, sober, cool, of good judgment and discretion, a dependable man, one to whom the superintendent of a water-works system may intrust the care and safety of that system when he withdraws from the day's work and when he retires for his nightly sleep, with a feeling of confidence that matters will be handled properly in his absence.

Such a man is usually found in every large water-works system, but not in great profusion. By careful observation he may be discerned, and the wise and far-seeing superintendent noting his good points keeps him in his mind's eye, nurses him along, gives him opportunities to develop his confidence and special qualifications, encourages him to study the pipe system with its ramifications, to the end that he may know the effect of closing or opening various valves, and, when the time is ripe and the opportunity comes, the right man is ready for the place.

The tools essential to the efficient operation of an emergency force are as follows:

Heavy wrenches for the operation of large gates. These usually are made with detachable handles. T-handles are used in some

cases, and crosses or four-arm handles are used in others. The latter kind allows of a more continuous movement, it allows each man to apply his force more directly and with less wasted energy than with the T-handles, where hand room is limited and the men are more crowded in their movements. More leverage can be obtained with either handle by the use of extensions in the form of short pieces of iron pipe, or hand spikes set into sockets on the handle of the wrench. Norway iron is the best material for wrenches because of its toughness. Steel is more brittle and liable to break in cold weather. The wrench should be as short as practicable. The gate nut should be brought to a uniform distance below the street surface by means of an extension permanently attached and in place under ground. A recently made device, in the shape of a long hollow-steel wrench with an adjustable handle, appears to do away with the necessity of these extensions. The wrench is made of square steel tubing, and is long enough to reach a deeply buried gate. The handle moves up and down along the wrench column. It can be placed at a convenient height and kept in place by a pin passing through holes bored at intervals through the wrench rod. It is light and efficient.

Other wrenches lighter in make should be carried for operating the smaller size gates. It is well to have a wrench with an open socket equipped with sliding wedges. These are of much value where the stem nut is smaller than usual or where the corners of the nut have been worn smooth.

Wrenches for corporation and curb cocks, hydrants, air valves, etc., should also be carried.

Monkey and Stillson wrenches are required at times; also calking tools, driving and sledge hammers, crowbar, picks and shovels, a stiff broom, a hand pump, a long-handled spoon to remove dirt from gate boxes, white and red lanterns, and a strong light with reflector to locate gates and gate marks at night. A good light is made of a small acetylene gas tank such as was used to furnish gas for the headlights of automobiles before electric lighting became so common. A burner and reflector may be attached to the tank, and the whole outfit suspended by bands and a handle, so that it may be carried by hand and the rays of light sent in any direction. The headlights of the auto may also be utilized to a certain extent.

A gasoline or kerosene torch, such as is used by railroad men to thaw out frogs and switches, is useful in winter to thaw out frozen gate covers and melt the ice that sometimes forms in small gate boxes which fill with mud and water.

Connection pieces to replace, temporarily, frozen, leaky, and stopped meters are useful. A force pump to clear out stoppages, and other fittings that may be applied as first aid in time of trouble, should also be included.

Hip rubber boots should be furnished the men, and they should have suitable storm clothing as protection against the weather.

A useful adjunct to the equipment is a powerful lifting jack. Frequently a heavily loaded team sinks into a soft spot in the street caused by a leak, and it is good policy to assist in extricating it, thus minimizing the loss of time which will be included in the claim for damages that is certain to follow.

Plans should be carried on the car, showing the pipe system in a condensed form, at a scale of 200 or 400 ft. to the inch. These should be in the form of blueprints and kept up to date. They are of great help to the men, especially when they answer calls in new territory or in some suburban district where they are not well acquainted with the pipe lines.

A gate finder is also useful at times, especially so in cases where tarvia and other bituminous preparations are spread upon the streets and become soft and plastic and " crawl " under the rolling motion of traffic, covering the gate boxes by a thin layer. The gate finder is a magnetized needle which is deflected towards the ground when it passes over the iron cover.*

In Boston we have a more positive way of locating our gates. A distance mark is stenciled on a fence, pole, or building directly opposite the gate if possible, telling the number of feet from the mark out to the gate. If it is not possible to place the mark opposite the gate, it tells the distance between the mark and a point opposite the gate. A stenciled arrow shows the direction, right or left of the mark, that one must measure to get the opposite point. In other words, the mark gives the base and perpendicular of a right-angle triangle, the apex of the triangle being the gate. Sometimes these marks are black on white ground, other times the

* JOURNAL N. E. W. W. A., XXVIII, 294.

reverse, according to the color of the background. The object is to make them as conspicuous as possible, especially at night. When the ground is covered with snow, these marks are invaluable. In squares and intersections where there are many gates, a sign is erected on a post with the distances for all the gates tied from the one point, viz., the post. This makes unnecessary a number of marks on the corners and sides of the squares or intersections and concentrates the information at one point. The sign is not unsightly. It has gold letters on a dark-blue smalt ground, and is similar in outline and general appearance to the street name signs.

A measuring tape is a necessity in connection with the gate distance marks.

The automobile should be in the form of a truck with a specially designed body suitable for the carriage of men. The best arrangement is to have the seats run lengthwise with the body and use the space under the seats for the storage of wrenches, tools, etc. The body should be accessible from the rear by means of a hanging step. It should be a powerful car of not less than 40 h.p., preferably more, if there are hilly sections to cover, and if the city is located where the snow falls frequently and to some depth. It should have tires of ample size to carry the maximum load. It should be equipped with demountable rims and carry an inflated spare tire. The tires should be of the best quality and kept inflated to the limit at all times. It will be found that this will give better service and will prove more economical in the end. In fact, it will pay in every way to get a good car even if the first cost is high rather than to buy a cheap outfit that will fail you at the critical moment and will be in the repair shop a considerable portion of its life. It is well to have the car equipped with a warning signal similar to the fire department, viz., a bell with swinging tongue, otherwise traffic will pay no attention to your efforts to get a right-of-way.

In Boston we have an emergency car with body of special design, seats running lengthwise. Exclusive of the chauffeur, it can easily carry 14 men. It has a top with side curtains, and is fairly comfortable in the most inclement weather. The chassis is a White, 40 h.p., built in 1911, and is still doing good work with no prospect of our replacing it with a later model. The first

17 000 miles of the car cost us practically nothing except for oil, gasoline, and tires. Since then, considering the nature of the service and the severe conditions under which the car is run, it has given very good results. Twice in five years it has been overhauled, and with the exception of a spring leaf breaking, or a wheel bearing becoming loose, or a brake band wearing, no trouble has been experienced since the last overhauling. It has traveled about 37 000 miles up to date. We have among our other cars one of similar make to our emergency car, with body suitable for emergency and general department work combined. This car serves at times to take the place of the emergency car should anything happen to put that car out of service. It is a safe precaution to have another car in service to serve as a substitute for the emergency car, as, no matter how good the car may be, or how carefully it is run, there is always the possibility of its meeting with an accident.

The duty of the car as we use it in Boston is very severe. It is operated twenty-four hours a day by four different chauffeurs. It cannot choose its route, but must travel in the most direct way to the place it is summoned. The pavements may be rough or smooth, the stopping and starting frequent. Such conditions are a great strain on an automobile.

The car averages about 200 trips a month. Each trip averages 3½ miles. As the department operates 16 additional automobiles, 8 of which are trucks, much business that would ordinarily be done by the emergency car is done by these trucks. Our policy is to keep the emergency car and its crew in quarters as much as possible, so that when a real occasion for its use arises it is on the spot ready for business, and not two or three miles away, engaged in some unimportant work that could easily wait until it can be cared for through the regular channels of business. As it is, it answers many false alarms. A plumber desirous of having the water shut off to enable him to make repairs will sometimes telephone that a pipe is broken in the cellar and is doing great damage. We hasten to the scene only to find that the owner or plumber desires the water turned on or off and he did not wish to wait to have it done in the regular way. As for damage, there was none; nor any possibility of any.

At other times during a heavy rainstorm we are called upon to stop the entrance of surface water to cellars, or the backing-up of over-filled sewers. During a recent heavy rain our office received over forty calls for assistance in one hour between 5 and 6 P.M.

We are also called upon to extricate horses from manholes and trenches into which they have fallen, and in a variety of ways are requested to attend to matters either outside our regular line or such as could not properly be classed as emergencies.

The emergency gang as operated in Boston is divided into three eight-hour shifts, each in charge of a leader. The day shift consists of four men including the leader. Each of the night shifts consists of six men including the leader. There is, besides, a man on duty in the office during each of the night shifts and on Sundays and holidays. He attends the telephone and takes all messages and notifications and directs the emergency gang to the point of trouble.

Owing to the eight-hour law, we cannot work the men more than six days a week. It is therefore necessary for each man to suspend his work one day in seven. This is so arranged that there will be but one man off on each shift each day. This practice of laying the men off one day in seven reduces the number of men available by one the greater part of the week. To offset this we were obliged to add one more man to each shift to serve as a substitute during the absence of a regular man on his night off or during his vacation. Some risk is attached to laying off the leader, as he is the most capable man, and the most serious break is likely to occur the night he is off.

Most of the calls could be attended to by one or two men, but, as we do not know when the big job will come, it is necessary to have a sufficient number of men on hand at all times to meet it. During the day it is always possible to get assistance in handling large gates, but at night it is practically impossible. Therefore, in the event of a break in the lines of large diameter with water flowing at a great velocity through the valves, it is necessary to have at least five men to close the 36-in. gates that control the same. Arrangements are made so that in the event of a very difficult shut-down, where several large gates have to be operated

against a strong head, other men on duty in the stable and fire room may be called out to assist.

A device invented by the writer has proved itself capable of great service in the operation of large gates. It is incorporated in the mechanism of the automobile emergency car and consists of a universal wrench socket actuated by a worm gear, placed within a housing on the side footboard of the car in such a position that it can easily be brought over the gate manhole in the street. When the car is in position over the manhole, a wrench is slipped through the socket and fits on the stem nut of the gate below. The universal wrench socket, together with a universal joint on the end of the wrench, affords flexibility in case the car is not on level ground or the wrench socket not directly over the stem-nut. It is an easy matter, however, for the chauffeur to bring his car into the right position. The worm gear that actuates the wrench socket is driven by a horizontal shaft leading from a gear case back of the regular transmission of the auto. This gear case encloses a sliding gear clutch incorporated in and acting directly upon the driving shaft of the car. The gear clutch has teeth on both ends, that engage with internal gears according to its position. It is operated by a lever placed upon the side of the car and easily accessible to the operator. It has three positions, — one where its rear end engages with an internal gear that turns the driving shaft of the car; one where its front end engages with an internal gear that externally meshes with the pinion of the horizontal shaft that drives the worm gear, which in turn actuates the wrench socket; and a neutral position where everything is idle. In closing gates, the forward speeds of the auto are used. In opening, the reverse is used. All gears are made of chrome or nickel steel. All bearings are ball bearings, and all parts except the horizontal shaft are housed in aluminum. The housing is firmly bolted to the frame of the chassis and well braced to resist torque. The wrench used is a hollow square steel tube terminating in a specially hardened steel socket with universal joint between socket and tube. As fast as possible, gates are being equipped with indicators showing position of valve and informing the operator when the valve is seated or entirely opened. Where indicators are not attached as yet to gates, a counter is used. It is placed on the

upper end of the wrench and records the number of revolutions made by the wrench. As a means of safety in the event of the valve seating with force, or unexpectedly, a pin of known strength, placed in the universal joint of the wrench, shears off and breaks the line of power between the engine and the gate and prevents damage to either the gate or the gate operating device.

The machine takes up little space and does not interfere in the least with the ordinary use of the auto.

We have used the device to some extent in ordinary maintenance work, i.e., the closing and opening of gates incidental to repairs and changes in the pipe system. We have also used it to a limited extent as an adjunct of gate inspection, running the valve down and up to observe its operation and to facilitate its movement. Fortunately, however, our opportunity to use it as a real emergency device has been limited to one occasion, a few months ago, when our 42-in. high-service main broke in Copley Square. An entire length of a pipe was broken out, and water under one hundred pounds pressure gushed out and spread itself over the square. The asphalt pavement, with its concrete base, served to keep the water underground for a short time, and this — together with the fact that a 20-in., a 12-in., and an 8-in. main are laid nearby — caused our men a little uncertainty as to which main was broken, and some valuable time was lost in operating gates on these lines. When there was no question that the break was in the 42-in. line, they proceeded to shut the two 36-in. gates controlling the same. They are located about a mile apart. One has a 6-in. by-pass, but the other is without one. They started on the one without the by-pass first, and in their excitement forgot to utilize the gate-closing device on the emergency car. As a result their progress was slow, as was naturally to be expected with such head and velocity against the descending valve plug. Almost three quarters of an hour had been spent on this gate when the writer arrived and directed the closing of the other gate. The machine was used, and this gate was closed in twelve minutes. We then returned to the first gate which was not completely closed, but the resistance had been so great in lowering it by hand that it seemed as if some obstruction must have been in the seat of the valve. Rather than lose any more time on it, I had a 36-in. gate

and a 20-in. gate back of it quickly closed by the machine, and after opening a blow-off in that section, the pressure was removed and the obstreperous gate completely closed.

I am confident that if the men had applied the gate-closing machine in the first place they would have quickly closed the gate, or, if not, so much so that the flow would have been throttled down to that of a 6-in. or 10-in. pipe, and they could then have closed the gates behind it and operated the blow-off and completely shut the gate. Some valuable lessons were learned from the experience, and the confidence of the men in the efficiency of the gate-closing machine increased. No great damage resulted from the break, as it had a large area in which to spread, and catch basins drained it off. It demonstrated the value of catch basins, of which there cannot be too many, and it suggested the desirability of removing sewer manhole covers as an extra means of draining off the water before it finds its way into basements and cellars.

It also suggested the importance of having a by-pass attached to every large gate, to assist in equalizing the pressure on both sides of the gate during the descent of the valve-plug.

The delay in the early moments of the break, caused by an uncertainty as to which of the several mains was broken, proves the undesirability of laying several large-sized mains in a single city street. In Boston, where the streets in general are not noted for their width, we have many cases of two and three large mains laid within narrow limits. At the intersection of Tremont Street and Columbus Avenue, we have one 30-in. low, one 30-in. high, one 36-in. low, one 24-in. low, one 20-in. high, and several 12-in. high and low service mains. In a narrow way called Chardon Street, we have laid, as closely together as possible, one 30-in. low, one 24-in. low, one 10-in. low, and one 16-in. high service main. In Tremont at Boylston Street we have one 40-in., one 30-in., and two 12-in. mains laid closely together; and branching into Boylston Street, easterly, are one 16-in. and one 30-in.; and branching westerly are 8-in. and 12-in. mains. In addition to all this, we have a new high-pressure fire-service main. In Huntington Avenue, near Francis Street, we have laid, with very little distance between, one 42-in., one 36-in., one 30-in., one 20-in., and one 12-in. mains.

These are a few examples of many similar situations, and are cited here merely to show the difficulty confronting an emergency-man in any of these locations, accompanied only by three or four helpers, at about 3 A.M. on a stormy morning with the wind blowing a gale, the ground covered with snow, sleet blinding the eyes, and a tremendous volume of water gushing from the earth, destroying the pavement, making dangerous holes here and there, and covering beyond all hope of access manholes wherein are located the valves controlling the different mains. The question that surges up in his mind is, "Which of the mains is gone?" He must have powers beyond those possessed by mortal man to decide quickly and accurately. There is nothing he can do except to approximate as nearly as he can which main has failed and then proceed to shut off that one, and if the flow continues, try another, and another, and so on until he strikes the right one. It so happens in the ordinary course of human events that not infrequently he makes the right selection last.

Another aspect of this matter of laying several mains in proximity to each other is the danger to the other mains caused by the washout from the broken one. As I said before, "disturbance" is greatly to be feared in connection with water pipes, and here we not only have a disturbance but in many cases an upheaval.

When the emergency car is dispatched to answer a call, one man is left behind at headquarters unless the notification makes it plain that a serious job is at hand. The man at the telephone can usually tell by the number and rapidity of the telephone calls. Where there is a break of large dimensions, the average citizen considers it his duty to inform the water, police, or fire department, whichever in his judgment is the proper one, and the result is an avalanche of notifications directed to the Water Department. As a rule, there is no mistaking real trouble by this sign alone.

The man left behind at emergency headquarters is available in the event of another call coming in after the car has left in response to the first call. It is sometimes the case that the gang is sent out on a trivial matter and a few minutes after its departure notice is received of a serious leak. The man left at quarters responds with a horse and light wagon, and if possible he controls the situation

himself. If it is beyond his ability, he telephones to the office. In the meantime the office man has been getting in touch with the emergency car and has in all probability directed it to the scene of the second leak. He has done so by use of the telephone. Telephones are in such general use at present that it is almost always possible to ask the occupant of a house or store in the vicinity of where the car was called to step outside and summon one of our men to the 'phone. If this is not possible, we can always reach our men through the police. The man on duty in the police station receives reports from the officers outside through the signal boxes. He communicates with the officer on whose route the car is supposed to be and has him convey to our men any directions we may see fit to give. Furthermore, it is a rule of the emergency service that as soon as practicable after arriving on a job the man in charge of the gang is to telephone the office as to his whereabouts, and the nature of the trouble, and receive instructions from the office as to his next move. In this way we save time and travel by moving the car from job to job rather than have it return to quarters after each one.

It has been customary, during the last few years, to have the emergency gang report at all large fires, the object being to render any aid that it can in connection with the water supply. In the case of a very large fire, where the supply is insufficient, it may be possible to reinforce it by opening division gates that are usually kept closed to separate high- and low-pressure systems. If the fire is in the vicinity of the boundary line of the city, gates may be opened admitting the supply from some adjacent town or city. If a hydrant becomes inoperative, it may be possible to make it serviceable; or if a hydrant breaks away from its fastening, gates may be operated in such a manner as to stop the flow of escaping water without interfering with the supply of the other engines. Pipes of large size entering buildings on fire usually break off inside the building as the fire progresses and the building collapses. Unless these pipes are shut off the pressure in the mains is decreased to a point where the efficiency of the fire department is imperiled. In many such cases the emergency gang is of value in shutting off these pipes in the street. Modern practice requires the presence of skilled water-service men at a large fire for

the same general reason as that which requires the presence of gas men, electric-light men, telephone men, and street railway men.

As we look back over a period of years, the wonder is how we ever managed to attend properly to the troubles of a large water system without the assistance of a well-organized and rapidly-moving emergency gang. We find somewhat of an explanation in the following facts: that the public did not expect such prompt and efficient service as it does to-day; that the public was not so prone to exact damages for the slightest wetting of its property; that litigation was not entered into so cheerfully and freely over the merest pretext as to-day; that pipes were not so old; that they were laid with more thoroughness and less haste than to-day; that they were laid under better conditions, with more room and less occasion for crooked lines; that there was practically no disturbance to the pipes or their surroundings once they were laid; that there is higher pressure as a rule in the pipes now than formerly; that there are more pipes and larger pipes; that modern plumbing is of a highly complicated and elaborate type, involving a greater and more constant supply; that there are more hydrants and of a type that project above the surface of the street; that there are thousands of automobiles moving at a quick pace throughout the streets day and night; that there are reckless and irresponsible drivers operating these automobiles; that the automobiles under the influence of such drivers come in violent contact with hydrants, the consequences being obvious to the water-works man; and that in general, modern civilization, as it is found to-day in large cities with its virtues and vices, its characteristics and methods, its utilities and luxuries, makes the emergency gang in a water service a fixed necessity just as the ambulance and relief hospital are established adjuncts of the regular hospital; as the automobile fire apparatus has superseded the old hand- and horse-drawn engines; as the automobile police patrol has replaced that crude, exhausting method of dragging the drunk through the streets to the police station; as the powerful and luxurious trolley has replaced the stagecoach and horse car, and so on throughout all lines of modern life.

The well-organized and properly-conducted emergency service in a water department of any large city of to-day is a valuable

asset. Beyond its efficiency in its own special line, whereby it saves money by minimizing property losses and public inconvenience, it serves as a stimulant to the department of which it is a part, to keep its system up to a high standard of efficiency. The emergency gang in the course of its regular work is constantly uncovering weak spots in the system. A gate is found defective, covered up, or the box filled with mud. A hydrant is found out of order and in such a condition that it cannot be used at a fire. Service connections are found to have no shut-offs or else defective ones. The absence of a gate mark is noted. The need of more gates on certain lines is shown; the advantage of a blow-off here or an air valve there, and so on.

A smoothly-working emergency service implies a water system with its fixtures in good working order. While the mechanical elements of an emergency outfit are an essential part of the same, yet the factor of prime importance, in that as in all lines of public service, is the human element. If that is of high standard, the rest will rise to the same level almost automatically.

To have the personnel of not only our emergency service but of all branches of our water works of a high moral, mental, and physical standard should be the constant aim and effort of every waterworks man holding an official position of high or low degree.

METER RECORDS FOR SMALL WATER WORKS.

BY A. W. F. BROWN, SUPERINTENDENT, FITCHBURG, MASS.

[*Read September 15, 1916*]

From our experience, the three forms submitted have been found to supply the needs of recording the service given by a meter and furnish information that will help to settle the problem of the best meter for a place to use.

Form A is used for all tests of meters, and, as it can be filed in a loose-leaf binder, saves the extra work of copying the tests. The test slip is filed under the size, make, and number of the meter, and all subsequent tests of this same meter are filed with the first one, so a complete record of the service of the meter is had at any time from these slips.

Form B consists of two slips, a white and a pink duplicate, which are filled out in the office, and the white one is given to the meter men to install a new meter or change an old one. When the meter is set, the slip is filled out and returned to the office and the pink one is filled out to correspond. The pink slip remaining in the office gives a record of the meters unset, and, if those given to the men should be lost, furnishes the names for a new list. It is easy at the end of the year to take the data needed to figure the service for Form C from these slips by sorting the different makes and sizes together, after which the slips are filed in a binder for any further reference that occurs.

Form C, a card 5 in. by 8 in., is an effort to figure the make of meter that is giving the best service, all things considered, and, by actual costs, brace up the opinion that one has formed of the best meter to use. The costs of the repairs on each make and size can be filled in during the year from the bills for repairs, and the totals of cubic feet registered and length of service are obtained from the Form B slips at the end of the year. The expense is so divided up under these headings that a clear understanding of the service of your meters is before you at any time.

Form A.

Size of Streams.	Per Cent. of water delivered into tank. TESTS. No. 1.	No. 2.	No. 3.	Feet Run.	Pressure at Outlet.	
						Fitchburg Water Works, Meter Test No.
						From
						Street
4"						Make Size
3"						No. Reading
2½"						New Old Repaired
2"						Date test No. 1 No. 2 No. 3
1½"						Read test No. 1 No. 2 No. 3
1"						Test No. 1 Makers; No. 2 bef. clean; No. 3 aft. cleaning
¾"						Clock speeded up Inter. gear
½"						Stuffing box tightened repacked
⅜"						Parts broken
¼"						
3/16"						Ft. run in ser. since test No. 1
5/32"						Removed from ser. because
⅛"						In service, Years months
3/32"						Disposition of Meter
1/16"						
1/32"						Inspector
Average						Form A.

If this is first test of new or repaired meter, fill in column No. 1; if not, use column No. 2, or No. 3.

Form B.

Meter Orders

FITCHBURG WATER WORKS

Mr. ____________________

____________________ Street

____

Reason ____________________

Date of order ____________________

NEW

Size ____________ Make ____________

No. ____________ Read ____________

____

OLD

Size ____________ Make ____________

No. ____________ Read ____________

Date of Setting ____________________

Form C.

Size **Make** **Repair Card**

D. of R.	T. N. M. in S.	T. N. M. R. 1	% of M. R. 2	T. C. of R. 3	C. R. per M. S. 4	T. first C. M. R. 5	% of R. to first C. 6	T. N. M. O. R.	T. C. O. R.	C. per M. in S.O.R.	T. N. M. frozen	C. of R. frozen M.	C. per M. in S.	T. N. dam by heat.	C. of R. by heat.	7	8	Av. L. of S. y. m.	T. duty performed cu. ft. reg. 9	C. of R. 1 000 cu. ft. reg. 10	Av. F. C. of M. to D. 11

Total number of meters in service figured only on this size and make. Abbrev.: Av., average; C, cost; D, date; F, final; L, length; M, meter; N, number; O, ordinary; R, repairs; S, service; T, total. No. 7, N. M., worn out, spoiled or exchanged. No. 8, net cost of replacing No. 7 with new meters and is figured in Nos. 1-2-3-4-5-6-9-10-11. Nos. 1-2-3-4-5-6-9-10-11 include cost of repairs caused by frost or heat.

A SUGGESTION THAT THE ASSOCIATION APPOINT A COMMITTEE TO PREPARE STANDARD SPECIFICATIONS FOR WATER METERS.

BY ROBT. J. THOMAS.

[*Read September 15, 1916.*]

Should the New England Water Works Association appoint a committee to prepare standard specifications for water meters, as they have for cast-iron pipe and fire hydrants? That this is "some" question is fully appreciated, but, whatever the answer may be, it is believed its discussion will not prove unprofitable. Considerable money is expended in the purchase of meters, and cost of repairs is an important item.

If the superintendent of a municipally-owned plant could go into the open market and buy the meter which his experience shows to be, in the long run, the best and cheapest, then — provided his conclusions are based on actual test and repair records and are not simply the result of a predilection for some particular sales force — the purchase of meters would be logical and simple; but these conditions very seldom obtain at the present time.

Instead of this, in many cities and towns, ordinance requires the obtaining of bids and the awarding of the contract to the lowest responsible bidder. Under such conditions specifications are necessary, and, to any one who has examined those now in use, it is clearly evident that here is an opportunity for this Association to be of service. A great majority of present specifications contain simply a few broad requirements which all meters can meet — the bidders being generally requested to submit a description of the materials used, the weight and the greatest proper capacity of the meter. Frequently no statement is made as to the rate of testing, general accuracy, or sensitiveness. Sometimes it is stated that tests will be made with streams of certain diameters, but without expressing the test pressure, which is about the same as saying that a linear dimension shall be as long as a piece of string.

Almost never is anything specified as to the maximum allowable loss of head for certain discharges, and yet in many cases the loss of head through a meter may determine whether a good stream can be supplied on the higher levels of the distribution system, and some $\frac{5}{8}$-in. meters have no more loss of head for a certain flow than other $\frac{3}{4}$-in. meters. Again, the rates under which tests are made and the accuracy required differ widely and are not expressed in the same terms. Finally, little or nothing appears, in any specification which has been available for examination, that covers maintained accuracy or sensitiveness after use, which is really the most vital consideration, and there is small indication in any of the specifications that actual repair-shop records have been made the basis of requirements covering the method of constructing the meter. In some few specifications, the number of nutations is limited, and, in some, reinforcement of the disk or the use of a thrust roller is required.

It would seem, therefore, that this field of meter specifications might be profitably cultivated by this Association.

The best information for determining the specifications necessary for the best results is presumably to be found in department test and repair-shop records. Here, if anywhere, can be found the data to show the factors essential to durability, low repair cost, and maintained accuracy; and apparently one of the first steps towards the development of rational specifications is the collection and comparison of these records. The durability of meters as shown by shop records should never be lost sight of. For, no matter how easy a meter is to repair, if those repairs occur frequently, considerable revenue is lost by failure to register, not to mention the friction which is bound to arise between the office and the water taker in consequence of interrupted service.

How much more do we superintendents know about meters to-day than we did in 1895, when John Thompson presented a paper before this Association, and Clemens Herschel proposed that we conduct tests of meters? Does reinforcement of the disk or a thrust roller actually reduce breakages without loss of accuracy at low flows? Is depreciation more rapid with increased rate of nutation? Does the straight reading dial, with its mutilated gear-train, increase friction and so lessen sensibility? In

general; what are the construction features necessary to long life of meter, low repair cost, and maintained accuracy? Who can answer these and many other questions of practical import by reference to the records of his testing plant and repair shop? A record of meters taken out, maintained by a department for several years, showed 6 per cent. to 15 per cent. stopped or taken out yearly.

It would seem that this Association might profitably undertake the collection of the records of meter repairs and of tests made of meters when new and after certain periods of use. This is not a suggestion that this Association test meters, but rather that it collect by circular a digest of the information already in the repair shops and test records of many departments; or, if such records are not now in workable shape, that some standard form of keeping and reporting the information necessary to the determination of the relative durability and continued accuracy of meters be developed and adopted for use by the members of this Association.

It is fully realized that local conditions vary, and that the controlling factor in the life history of a meter is the character of the water, but the average of results obtained from many water systems, especially since the quality of the water served has been generally improved, could not fail to show relative durability and relative continued accuracy, and from such a digest of present or future records, it should be possible to devise standard specifications which would justify the acceptance of the lowest bid offered.

In the meantime, and before such records could be collected and digested, it is believed that a tentative meter specification might be developed from a study of existing specifications. This specification could at least standardize requirements for accuracy and the method of testing and would be of considerable value.

I suggest for your discussion the appointment of a committee to consider and report on the feasibility of a standard specification for water meters, and on the advisability of attempting the collection of test and repair records in such a way as to determine, so far as possible, the relative durability and continued accuracy of meters.

DISCUSSION.

Mr. Thomas. I have some reports here, taken every year for five years, of different meters in use in the city of Lowell, where there are over 10 000 meters in use; and, taking a type of meters of which at least 100 are in use, I find that the first year, in 1907, 7 per cent. of this meter, which we will call No. 1, were taken out for repairs; 1908, 6 per cent; 1909, 7 per cent.; 1910, 8 per cent.; 1911, 7 per cent. Those meters had been in use a good many years, some of them for twenty-five years.

Another meter, we find 8 per cent. were taken the first year, 8 the second, 9 the fourth, 9 the fifth, and 9 the sixth, showing an improvement in the running of the meter.

We found another meter, the first year, had 14 per cent. taken out, 14 the second, down to 7 per cent. taken out the last year the record was kept. We have another meter which showed 12 per cent. the first year, 6 the second, 6 the third, 7 the fourth, and 3 per cent. the last year, which was a very good showing.

We have a meter of another make, but of about the same type, of which 11 per cent. were taken the first year, 21 per cent. the second year, 4 per cent. the third year, 7 per cent. the fourth year, and 14 per cent. the fifth year.

That, of course, gives no idea of the cost of repairing the meters. It was only to get a line on the meters that were the most constantly in use, the meters that you could rely on from year to year, — and of course that is an important factor; and we could not lose sight also of the expense of repairing the meters. A meter that will remain in use ten or fifteen years without any attention seems to me to be a better meter than one that will have to be taken out if only slight repairs are made on it, every two or three years.

There are a good many things to be considered in regard to the meter business. The percentage of registration which takes place on a meter which may be otherwise reliable and may be in use and may be giving results in the way of registration, but still there is a percentage of registration which may be far below perfect. However, my interest in this is all impersonal. I have not favored any meter, but I am anxious to see all the material that we use determined by standard, if possible, especially in

view of the practice of commission governments to call for bids and oblige you to accept the lowest one. We all know that in some cases the lowest-priced article is far from being the cheapest in the long run, and if we are going to call for bids and purchase in accordance with the lowest bid we want to have the strictest kind of specification, so the city will get value for the money that they expend.

MR. A. W. F. BROWN.* I have with me a few figures of what the cost of repairs has been for one year, taking in all kinds of meters; in fact, probably every make that is in general use:

Total number of meters in service	2 357
Total number of meters repaired	334
Total cost of repairs	$1,110.00
Cost of repairs to meters in service	.47
Total number of meters, ordinary repairs	260
Total cost of ordinary repairs	$647.00
Cost per meter in service, ordinary repairs	.27
Total number of meters frozen	20
Cost of repairs	$63.60
Cost per meter in service	.026
Number damaged by heat	7
Cost of repairs to meters damaged by heat	$22.75
Total duty performed, in cubic feet	9 028 500
Cost of repairs per 1 000 cu. ft. registration	.122

MR. BERTRAM BREWER.* The speaker had quite an experience, a year ago, in Waltham, in connection with buying meters. Up to this time the city had bought meters of various manufacturers, perhaps 100 of each. It seemed very necessary to reform the scheme and make sure that the city had as many of one kind of meters as possible. I suppose every superintendent of water works is up against that problem. Up to that time, we had about a dozen or fifteen different kinds of meters. We all know what it means to keep repair parts for that number. Tentative arrangements had been made to buy six or eight different kinds of meters for the year 1915, so it is easy to see that it was no small problem to decide just what to do. As one might conclude, the fairest and squarest way seemed to be to prepare specifications. It was the

* Registrar and Superintendent Water Works, Fitchburg, Mass.

* Superintendent of Sewers and Water Works, Waltham, Mass.

first time it had ever been done in the city, but we did it, and we received very satisfactory bids, and the manufacturers went out of their way to help us.

The point I was going to make was this: from what study we gave to the situation, it did not seem possible to buy the meters on the dollar-and-cent basis alone. One would never think of buying an automobile or any other machine on that basis, and therefore our specifications required two conditions, and we awarded the contract on the basis of the price, the quality, the workmanship, and makeup of the machine. We required everybody to submit a sample of the meter that he bid on, and the samples were very carefully analyzed by an expert, and, with all the facts before us, which were written down and given to the bidders who wanted them, we came to a very definite conclusion, and our results were very satisfactory, we think; and we ordered quite a number of meters of one kind, so we hope that the repair parts will not have to be of such large quantities as time goes on, if this policy is continued.

We also adopted a scheme of keeping records of the meters — the first time it had ever been done with us. Our meter sheet is rather simple (see Figs. 1 and 2). We put all the data on one sheet,—the test, the service in which the meter is installed, and the data that it was installed. We also have dates and lines in the sheet provided for the reading of the meters. Of course we always read the meter for the first week or two after it is installed, and keep the customer informed as to the condition or the use of water, especially if there is any waste. All these records, also the cost of installation and the cost of any repairs, are kept on these sheets, and they are filed away according to service numbers. I think this idea of records and a uniform system of keeping those records is a very important matter, and perhaps has not been emphasized enough. It seems to me it is just as important as the matter of the specifications, because, if one superintendent keeps the record one way and one another, it is very difficult to compile those records in such a way as to make them of any use.

Another point occurred to me that it is very difficult to dogmatize the suggestions, such as have been read to us to-day, about the number of repairs, or the percentage of meters that have been

JOB NO...............

WALTHAM WATER DEPARTMENT.

DAILY LABOR, PLANT, MATERIAL RECORD.

Date.	Laborer (or Plant).	Rate.	Hours.	Amount.	Total.	Remarks.

Date.	Material.	Unit.	Unit Cost.	Number.	Amount.	Total.	Remarks.

CORRECT......................FOREMAN.

FIG. 1.

This side is used for data on first cost and maintenance of meter.

WALTHAM WATER DEPARTMENT.

INSPECTION REPORT.

Date	

METER TEST: SIZE............NAME......................NO.................

Date.	Pressure Pounds.	Opening Inches.	Time.			Register Readings, Cu. Ft.			Percentage of Error.	Rate of Flow C. F. M.
			Start.	End.	Difference.	Start.	End.	Difference.		

CORRECT...................FOREMAN.

FIG. 2.

Reverse side of sheet is used for record of all inspections of metered service and for record of meter tests.

repaired from year to year, because there are a good many repairs of that kind that have to be made that cannot be charged up to the meter. The hot water and the connections often cause a great deal of trouble with the meters. Then we have trouble with dirt collecting in the meter. Those are two things which occur to me which cannot be exactly charged up to the meter itself, as the fault of the mechanism, and there may be others.

Mr. Sherman. In order that the matter may not drop, and that we may have some definite subject to talk about at the moment, I will make the motion suggested by Mr. Thomas's paper, that the Association appoint a committee to study into the desirability of formulating meter specifications.

Mr. King. I would like to amend the motion, in line with one suggestion Mr. Thomas made; that is, in line with the standardizing of the main parts, that the committee make an effort to standardize as many of the parts as possible.

Mr. Sherman. I accept the amendment.

The motion as amended was carried by a unanimous vote.

The President subsequently appointed the following committee: Charles W. Sherman, Boston, Mass., chairman; A. W. F. Brown, Fitchburg, Mass.; R. J. Thomas, Lowell, Mass.; William W. Brush, New York; James H. Mendell, Manchester, N. H.; Charles A. Finley, Pittsburg, Pa.

LEAKAGE FROM PIPE JOINTS.

BY F. A. BARBOUR.*

[*Read September 14, 1916.*]

On September 7, 1915, — as a result of a paper read by Mr. Arthur H. Smith before this Association, — a committee was appointed " to investigate experience in the leakage of pipe joints." This committee consists of Messrs. C. E. Davis, S. E. Killam, C. M. Saville, H. B. Machen, A. H. Smith, E. G. Bradbury, and the writer.

The present brief statement is not a progress report from the committee; rather it is made for the purpose of inducing a more active interest in the investigation by the members of the Association, and particularly with the hope that a discussion may result which will be of value in the further work of the committee. Any opinions expressed are the personal views of the writer and not of the committee.

As the best method of obtaining the results of experience in joint leakage, a circular containing 37 questions was mailed to 430 members of this Association, and to 124 members of the American Water Works Association. From the 554 circulars sent out, 131 replies have thus far been received, 46 of these being from the members of the American Water Works Association. Only 85 replies were received from the 430 circulars sent to the members of the New England Water Works Association. When only one in five members takes any notice of such a circular it is evident that either the subject of the investigation is of little moment, or else the members do not appreciate the value of cöoperation if any results of value are to be obtained.

It may be — and in regard to this it is hoped that members will to-day express their opinions — that leakage from pipe joints is not generally an important factor, and that the present type of joints driven and tested, or not tested, as may be the practice, is entirely satisfactory. It also may be, and probably is true, that such leakage from mains as does occur is not general, but is rather located in a few imperfectly-made joints; or, in other

* Consulting Engineer, Boston, Mass.

words, that the average present standard design and workmanship is good enough. While this may be true, it comprehends the subject chosen for investigation, and thus far little information of definite value in reaching any conclusion has been received by the committee.

One fact, however, stands out, namely, that even in the fully metered systems, about 20 per cent. of the total water supply is unaccounted for by sale to the consumers. Thus of the 131 replies received, 10 per cent. report the services to be entirely metered and 30 per cent. more than 85 per cent. metered, and the average water unaccounted for, as estimated in these systems, is 21 per cent. This loss is chargeable to leakage from mains or services, or to failure of the meters to register. It would seem to be worth while attempting to locate the cause of a 20 per cent. loss of the water furnished. If slippage of meters is the explanation, this simply means that consumers are getting more than they are nominally paying for, but, if leakage from the mains and services is responsible, the result is an absolute loss of water which costs money to develop and deliver to the distribution system.

The average consumption in the 40 systems in which 85 per cent. or more of the services are metered is, as reported, 68 gal. per day per capita. The average estimated unaccounted-for water was, therefore, equivalent to about 14 gal. per day per capita, or a loss of 5 000 gal. per year per capita, which, if the cost is estimated at $25.00 per million gallons of water delivered to the distribution system, is equivalent to a yearly cost per capita of 12½ cents, or approximately the interest on $2.00; in other words, a town of 10 000 people could afford to expend $20 000 in order to prevent this loss of 14 gal. per day per person.

If, then, in these fully metered systems, which undoubtedly represent the best condition, only 80 per cent. of the water supplied is sold to the consumers, the question arises as to whether this should be accepted as the highest standard of efficiency which can be reasonably attempted.

If, in any considerable part, the unaccounted-for water is chargeable to slippage of meters, then it would seem desirable that increased attention should be given to the subject of maintained accuracy and sensitiveness of meters.

If meter slippage is not the explanation of the unaccounted-for water, then the loss must be through leakage from the mains or services.

As to the loss from services, 80 per cent. of those replying to the circular estimate this to be small or none. As to the leakage from mains, 99 of the 131 answers received do not attempt to estimate this loss; 18 state it to be very small or none; and 14 estimate it in percentage of the total amount supplied, the average of these few figures being 15 per cent.

From the replies already received, therefore, — and these presumably are from those departments best able to answer the several questions, or most interested in the problem, — it is evident that, while undoubtedly a considerable portion of the water supplied is not sold to the consumer, there is little or no definite knowledge of the actual conditions of the pipe joints. The general impression, as indicated, is that the mains are fairly tight and that the leakage from services is small. It may also be inferred, from various notes in the replies received, that such leakage as may occur in mains is located at certain isolated joints and is not general.

One phase of the investigation as conceived by the committee was that in reference to the practice of testing pipes when laid. Believing that in the majority of cases local conditions would not permit the trenches to be kept open until the pipes were tested, the question was asked as to the reasonable allowable leakage in testing after backfilling, as determined by the measured water necessarily introduced to maintain the test pressure. Such a method of testing is of course not to be compared with the visual examination of the joints under pressure, but it is necessary in many cases.

Of the 131 replies received in reference to testing pipe when laid, 76 state such tests are made, 36 that no tests are attempted, and 19 that sometimes the pipes are tested and sometimes not. The interesting and rather surprising feature in these replies is that all but six of those who state that the pipe is tested report that the test is made before backfilling the trench. Further, of the 75 who replied to the question as to the standard of tightness required before putting the pipe in service, 63 state this require-

ment to be "absolute tightness." Of those who report that it is customary to test the pipe when laid, 85 per cent. state that the test is made under the working pressure which the pipe is to carry in service. Only 18 report tests in excess of working pressure, the test pressures ranging from 30 lb. excess to double the working pressure.

From the information received to date, it therefore appears that it is quite the general practice to test before backfilling and to require absolute tightness under the working pressure. If these replies can be accepted as expressing the general practice of water departments, it is evident that the present standard is high, and the only question which might profitably be asked is as to what happens to the joints when the higher pressures due to water ram, and more or less incident to the operation of every system, are applied, and whether, therefore, pipes should not be tested at some pressure above that of working conditions. It is noticeable that but very few of the statements made in reference to leakage from mains and services are based on any actual tests after the pipes have been in use for any period of time, and the opinions expressed are generally formed from observation of such joints as have from time to time been exposed. Only four definite statements of tests for leakage of pipe after periods of use are reported, and these indicate only a small loss from the joints.

Naturally, only those systems where a high percentage of the services are metered can make any accurate estimate of the water not delivered to consumers. Where less than 75 per cent. of the services are metered, waste by carelessness inside the premises of consumers is undoubtedly the great factor in determining the amount of water supplied — a condition which clearly stands out in the replies received, by comparing the water furnished per capita with the per cent. of metered services. Thus, with due allowance for special industrial demands, the relation between meters and amount supplied is very approximately as follows:

100	per cent.	metered,	68	gal.	per	day	per	capita.
75	”	”	75	”	”	”	”	”
50	”	”	90	”	”	”	”	”
25	”	”	110	”	”	”	”	”
0	”	”	125	”	”	”	”	”

It is therefore evident, as would be expected, without the evidence of the present investigation, that, in the conservation of our water supplies, metering of the services is the great factor, and leakage from mains, except in particular instances, is of minor importance.

While this is true, however, there remains the fact that in completely metered systems the average unaccounted-for water amounts to about 20 per cent. of the total amount of water delivered to the distribution pipes.

Whether it is economically possible to reduce this loss by a better type of joint, better workmanship, testing at pressures above normal, cannot be determined by the evidence thus far made available to the committee. The information most needed to reach conclusions is that giving the results of leakage surveys, of actual tests made after the pipes have been in service some years, of experimental work showing the relation between pressure on the joints and leakage, and, particularly, data from those departments where accurate tests have shown leakage in mains to exist. There is no doubt that in many cases there is a large loss from the pipe system, even though in the replies received to date to the circulars of the committee the great majority regard this loss as very small, or refuse to make any estimate.

The object of this brief preliminary consideration of the subject is to ask that members who have not replied to the circular do so at once, and particularly that any member who has at hand the results of definite leakage tests submit such information, which will of course be considered confidential.

An expression of the opinion of members on the general question as to whether further investigation of joint leakage is worth while would be of considerable interest.

DISCUSSION.

Mr. Barbour. The object of presenting this paper is to bring it to the attention of the members. The New England Water Works Association is in the habit of creating committees, perhaps too many of them. After they are created, the interest falls off. The committee cannot get any results without coöperation. As strongly as I can put it, I hope the members who have not replied

to that circular will do so, and particularly the men who have knowledge of leakage from pipe will tell us the results of any special investigations that have been made. Either that, or we have to assume the investigation is not worth while, and we might just as well drop it, and the committee so report.

Discussion at Meeting of November 8, 1916.

Mr. Barbour. This paper was written to stimulate discussion, with the hope that more definite data would be made available for the Committee on Leakage, rather than with the idea that it contains much information of definite value. Any conclusions which have been drawn from the information already furnished the committee are largely confirmatory of results which have been reached by other investigations.

The fact that in entirely metered systems, or in systems where the meters exceed 85 per cent. of the services, at least 20 per cent. of the water furnished is, on the average, unaccounted for, does, however, stand out, and the question arises as to whether we should be content with such a condition. It is to be noted that this 20 per cent. loss is not based on a comparison of pump records with the water sold, but on the figures furnished by superintendents as to the water unaccounted for in their systems, these figures presumably making corrections for such items as pump slippage. It would seem that a loss of 20 per cent., due to leakage from mains and services or to under-registration of meters, which undoubtedly represents the best conditions, is sufficiently sizable to justify careful consideration of possible remedies.

We all know that the total unaccounted-for water in unmetered systems is enormous; presumably we all agree that metering is the great remedy, and yet, as reported by the United States Department of Commerce, only 40 per cent. of the services are metered in 201 cities, containing 26 000 000 people and having an average per capita consumption of 139 gal. per day. This total loss is not the subject of our immediate discussion, but, as a means of calling attention to present standards of management, a few figures may not be amiss.

The total population in the United States supplied with water from public works may be taken, for present purposes, at fifty

million people, and the average amount of water furnished per day at 100 gal. per capita. The total water supplied daily by public works is, therefore, in round figures, 5 000 million gallons. It is probably a safe statement that 50 per cent. of this quantity is wasted, and assuming the actual cost of furnishing the useless 2 500 million gallons to be $25 per million gallons, — and this is an extremely low figure, — the cost per day of the water wasted is equal to $62 500, or $22 800 000 per year, which is equal to the interest on an investment of $500 000 000. Figured in this rough way, the results do not speak very well for our present-day standard of management of water systems. If it should be answered that it is not practicable to prevent this loss, a reasonable reply would be that at least we should know more about its causes than apparently is known at the present time.

As already stated, metering is the great means of reducing the total waste on which the previous figures are based, but there remains the fact that in the fully metered systems, on the average, at least 20 per cent. of the water furnished is unaccounted for, and probably if more accurate data were available, this percentage would be shown to be materially greater.

Emil Kuichling estimated 2 500 to 3 000 gal. per mile per day as the leakage from well-laid mains; Dexter Brackett estimated a leakage of from 10 000 to 15 000 gal. per day in the Metropolitan District; and John R. Freeman stated that his best guess of the underground leakage in New York was from 25 to 35 gal. per day per capita, equal to from 20 000 to 30 000 gal. per day per mile of pipe. In six cities, with 95 per cent. of the services metered, reported by Brackett in 1904, 36 per cent. of the water was unaccounted for, equal to an average loss of 11 300 gal. per mile of pipe. James H. Fuertes, in the 1906 Report to the Merchants Association of New York, presented statistics from thirteen cities in which on the average 82 per cent. of the services were metered, which showed that 31 per cent. of the supply was unaccounted for, equivalent to approximately 18 000 gal. per mile of pipe. What part of these losses are chargeable to the mains is unknown, but from the results of such leakage surveys as have been made, and from the reported actual losses discovered in some cities, it is probable that 7 500 gal. per mile of pipe per day is a conserva-

tive estimate of the water lost by leakage from the 60 000 miles of mains now in use in the public supplies of this country, or 450 million gallons daily. At $25 per million gallons, this is equal to a daily loss of $11 250, or $4 110 000 per year, or the interest on $100 000 000. In the light of this economic waste, it would therefore appear that the subject of leakage from mains is worthy of careful consideration.

The Committee on Water Consumption of this Association reported in 1913 * that "in general it may be said that if in a well-metered system the water unaccounted for does not exceed 25 per cent. of the total pumpage, the practice is good." Doubtless this should be interpreted to mean that a 25 per cent. loss is good compared with the average present practice; but is it good compared with the standard which should be set up in this age when we hear so much about conservation? Should we complacently accept a loss of 25 per cent. as inevitable, and, if this loss cannot reasonably be much reduced in the systems already constructed, what about the possibility of better methods of construction in the pipe to be laid in the future? It is, of course, out of the question to consider the relaying of present systems, or to do more than make leakage surveys and check the larger losses; but, in the light of present knowledge, is it not time to seriously undertake an analysis of the causes responsible for the present large percentage of water unaccounted for? If these losses are chargeable to under-registration of meters, then this should be definitely made known, and consideration given to the possibility of developing more sensitive or more accurate measuring apparatus.

Are we taking sufficient care in testing pipe for watertightness when laid? About 60 per cent. of those replying to the circular of the committee state that the pipe is tested when laid, and all but six make the test before backfilling. In the writer's experience, testing before backfilling in the ordinary work of laying distribution systems is rare, and it is undoubtedly from the practice of simply turning on the water without any test that a considerable part of the present leakage develops. The standard of those who test, as indicated by the replies received, is "abso-

* JOURNAL N. E. W. W. A., XXVII, 29.

lute tightness," but in the writer's experience this result is not easy to obtain, and only possible where the joints are gone over several times after the pressure is applied.

Where pipes are backfilled before testing, the allowable leakage, as determined by such test, has varied greatly in different specifications. John H. Gregory, at Columbus, made the limit 500 gal. per inch-mile per day. At Akron, 200 gal. per inch-mile per day was specified, while actual results at Akron showed about 70 gal. per inch-mile per day. E. G. Bradbury, in his paper before this Association in 1914,* proposed 100 gal. per inch-mile per day as a reasonable standard for the allowable leakage in testing after backfilling, and he figured that the difference between 500 and 100 gal. per inch-mile per day, estimating the cost of the water at $25 per million gallons, would equal a yearly cost for water lost in a city of 100 000 people, of $5 256, or, in other words, the city could afford to spend $470 per mile in order to save 400 gal. of leakage per inch-mile per day.

Again, are the present jointing methods the best qualified to maintain tightness after periods of use? Who knows anything about the comparative leakage when laid and after several years? In this latter connection the history of the work at Grandview, Ohio, is of interest. As reported by Mr. Bradbury, the supply is measured by a tested meter and all service pipes are metered. The 5.5 miles of pipe originally laid were tested before backfilling, and the leakage before any connections were made amounted to .31 gal. per inch-mile per day, or in other words, the system was practically watertight. Subsequently 0.9 miles of additional mains were laid, and gradually in the four years since the date of original construction the services have increased to the present number of 205. Either by less careful work in the extension or by depreciation of the original work, or by under-registration of the gradually increasing number of meters, the unaccounted-for water has increased until at the present time it averages about 150 gal. per inch-mile per day. An interesting feature in connection with these records is that the unaccounted-for water, based on three years' observations, averages 60 gal. per inch-mile per day during the six months from October to April, and 213 gal. dur-

* JOURNAL N. E. W. W. A., XXVIII, 315

ing the six months from April to October. In other words, the records indicate in this system that the unaccounted-for water is three times as great during the summer as during the winter months. Whether some local explanation can be found for this result, or whether it is a reasonable result of temperature changes is not known, but data from other systems showing the unaccounted-for water during periods of varying temperature would be of considerable interest.

Any information of definite tests of leakage from observation of mains after periods of use, or of the effect of temperature on leakage, or the results of tests of leakage from lead joints with different shapes of bell and spigot or of other types of joints, will be of value to the Committee on Leakage, and it is hoped that if any members have such information, and are not prepared to discuss the subject to-day, they will forward it to the committee.

MR. CHARLES W. SHERMAN.* When the committee's circular of inquiry was received, it did not seem to me that I had any data which would be of use to the committee. Mr. Barbour's paper has suggested a new line of thought and that data indicating more or less perfectly the causes of loss in a fully metered system are also of significance.

These notes relate to the experience of the town of Belmont, Mass., a residential community of 8 000 people, with no manufacturing, but where there is a considerable use of water by market gardeners. The water supply is obtained from the Metropolitan Water Works, and is metered at the town line, where it is furnished into the distribution pipes. The distribution system consists of 31.5 miles of main pipes 2 in. to 12 in. in diameter, and 14.75 miles of service pipe, with 1 430 services. It has been fully metered since 1898. The daily consumption for 1915 averaged 52 gal. per capita.

Not only are all the services (including municipal buildings) supplied with meters, but there are meters on watering troughs, etc., and the water department furnishes a man and a meter to measure the water used for sewer flushing. In fact, practically all the water used is metered, except that drawn from fire hydrants for extinguishing fires.

* Of Metcalf and Eddy, Consulting Engineers, Boston.

The proportion of the water supplied, which has been thus accounted for, has been as follows:

	Per Cent.
1908	67.2
1909	65.6
1910	58.5
1911	61.0
1912	62.3
1913	64.2
1914	71.9
1915	82.5

No definite data are available to indicate where the water unaccounted for goes. In 1910, following the decrease in the proportion for which we could account, it was thought that there must be considerable leaks in the main pipes, and great pains were taken to find such leaks. These efforts did not meet with much success. Some leaks were found, but none of material consequence, and, as shown by the percentages, the gain in the next three years amounted to only about 5 per cent. It was then concluded that greater care in looking after house meters might show a further gain. Previously they had received good ordinary care; they were supposed to be read monthly, and it was believed that a meter could not be stopped or in bad condition for any considerable period without discovery. However, beginning with 1914 a systematic following up of all meters was undertaken, and no meter was allowed to stay in service more than a certain limited time without removal, testing, and cleaning. This policy resulted in a gain of 7 per cent. in the water accounted for in the first year, and a further gain of 11 per cent. in the following year. How much more gain can be accomplished in this way, we do not know, but we are inclined to believe that not over 10 to 15 per cent. of the water supplied is lost through main pipe leaks, and it may be possible to account for between 85 and 88 per cent. of all the water supplied.

In this connection it may be interesting to note that in 1915, in the high-service district of Belmont, — a section including about two miles of 6-in. and 8-in. pipe (on a portion of which the pressure exceeds 160 lb. per square inch) and 47 services,— the per-

centage of the water supplied which was metered to consumers was 94.

Our experience here leads us to believe that with good work on the main pipes, the loss from joint leakage should not exceed 10 to 15 per cent. of the consumption; if the service meters leave more than this percentage unaccounted for, it is probable that the greatest gain can be made by close attention to meters.

This does not mean that joint leakage may be neglected. In my opinion, it does indicate that if, after thorough overhauling of meters, the percentage unaccounted for exceeds 15, there are probably main pipe losses which can and should be eliminated. If the total losses from leakage and under-registration of meters can be reduced to 5 or 6 per cent. we shall have made a long step in conservation, and one worth the expenditure of considerable sums of money.

Mr. D. A. Heffernan.* Milton's experiences in this line may be interesting to some. We have over fifty miles of mains, all cast iron, bell and spigot leaded joint, and about forty miles of services, brass, cast iron, cement-lined, enameled, galvanized, lead, plain iron, tarred iron, and tin-lined lead, averaging in length 109 ft.

In replying to the questions distributed by the committee, I answered the one asking for an estimate of the amount of leakage in our systems that it was practically nothing. And although we have not made an exhaustive test of tightness in the past five years, I reasoned this way.

Milton has been very successful in accounting for its water. In 1915, 85 per cent. of its water was accounted for by registration of meters. Four causes for the loss of unconsumed water may be accounted for in towns 100 per cent. metered, as is the case in Milton:

1. Slippage or under-registry of meters.
2. Use of water at fires and in blowing off.
3. Use of water in puddling.
4. Leakage.

Meters have been perfected in late years so much that slippage has become practically nothing. The under-registry is a point

* Superintendent of Water Works, Milton, Mass.

that amounts to considerable in municipalities that have been metering their systems for any number of years. When a meter has been in continuous service for fifteen or twenty years, it will be found upon testing that the consumer has been benefiting to the extent of from 10 per cent. to 30 per cent., varying with the type and size of meter. The remedy is to have a plan of removing and making repairs on a certain proportion of meters each year so that meters in service over five years will be the exception, not the rule.

A town with any number of dead ends can account for more of its water. Milton has upward of 100. These necessitate frequent blowing-off, each operation averaging fifteen or twenty minutes. Use of water at fires brings up another large factor. Of course, these last two points are necessary evils, one of which may, as time goes on, be diminished. I refer to the dead-end evil. A growing community must countenance the lack of complete circuits including the entire system. They can be put in connection gradually only in accord with steady growth in one district. But until these are completely conquered, comparatively tight systems will be looked on as embracing approximate perfection. Fires, of course, will always be, and unless each hydrant is metered, water thus used must be estimated, not accurately computed.

We come to water used in puddling the backfill. It is understood that we find an excuse for a rather small proportion under this heading. It is but another small outlet which helps make the total large.

Milton has, on the whole, a rather small percentage left for which leaks may be accused. This is borne out by figures of the night flow. In 1912, Milton used between 1 and 4 A.M. 12 gal. daily per capita. The next year the flow decreased to 10, which it has steadily maintained since, the lowest in the Metropolitan district.

Both service and main work is tested under working pressure before backfilling. Installing gates at frequent intervals to accomplish this is avoided by means of a testing plug used on 2-in. work and over. Milton does all its work, and, therefore, is in a position to know that all construction is done under the best possible conditions and that nothing is skimped.

It has been my experience while connected with the Milton Water Department that the great majority of leaks are from causes foreign to the water system. Almost 95 per cent. of the main leaks may be attributed to cross trenches settling and carrying the water pipe down. In many service leaks I blame the leak on the condition of the soil; for example, ashes eat quickly into lead pipe.

On the whole, I do not consider that anything is radically wrong with our present method of pipe laying, but if it is possible to approach nearer to the unattainable absolutely tight system, I am with you.

COMMITTEE ON METER RATES. REPORT ON WASTE; TO WHICH IS ADDED SUGGESTIONS FOR SERVICE CHARGES FOR LARGE METERS.

[*Presented November 8, 1916.*]

Your Committee on Meter Rates presented a preliminary report on September 9, 1914, and a final report on February 9, 1916, on the subject originally referred to it. At the March, 1915, meeting, after the presentation of the preliminary report, your committee was instructed to investigate and report upon "the water unaccounted for or lost in leakage," because "that question also is involved in meter rates and it would be desirable to secure more exact information upon it."

Pursuant to this instruction, your committee has collected statistics as to the use and loss of water, and other allied matters, from a number of completely metered systems, and it now presents these statistics, with some comments thereon. These records show the normal distribution of business among large and small consumers and among large and small meters.

With the aid of this information, the committee now makes a suggestion with reference to service charges for meters from $\frac{3}{4}$ to 6 in. in size. In the preliminary report such a suggestion was made for an appropriate service charge for a $\frac{5}{8}$-in. meter. Data at the committee's disposal at that time did not warrant extending the suggestion to larger meters. With the aid of the information now available, the committee now adds this study (which it considers suggestive rather than final and definite) to the Association for consideration.

WATER UNACCOUNTED FOR.

Upon being instructed to investigate water unaccounted for, the committee was somewhat in doubt as to what investigation it could wisely make. A number of methods of approaching the problem were discussed. Some of these involved experimental

work that the committee did not feel that it could carry out. It was then decided to make an inquiry for statistics of members of this Association and others having in their charge completely metered water-works systems. Systems having more than 90 per cent. of all their services metered (those remaining unmetered being limited ordinarily to single-faucet houses) were considered as completely metered. As it turned out, however, the number of unmetered services in the systems for which statistics were obtained was less than one per cent. of the whole number. It was thought by the committee that statistics for systems less completely metered would be of little use in this connection.

In the circular letter which was issued, information was asked as to the quantities of water supplied, sold by meter, otherwise accurately measured or estimated, and as to the quantities of water which could not be accounted for. The opportunity was also taken to get information as to a number of allied matters. In regard to a few of these matters, the information was so incomplete that nothing was done with it, but in other directions very gratifying returns were received and the statistics resulting from them should be of considerable assistance.

Returns were received from thirty-five systems that were completely metered or very nearly so. Sixteen systems were in New England. The others were well scattered over the United States, and one was in Canada.

These statistics were furnished by officers of water works of whom nineteen were members and sixteen were not members of the Association. They were given in some cases in great detail and represented a large amount of patient labor. The thanks of the committee is due to those who took so much trouble in their behalf, and especially to those who were not members of the Association.

These statistics have been summarized and are briefly set forth in the following condensed table. They are given in more detail in a larger table which accompanies this report, and which shows the most important data for each plant. Reference is made to this large table for all further details. (See Plate XV.)

PLATE XV.
N. E. W. W. ASSOCIATION.
VOL. XXX.
REPORT OF COMMITTEE ON
METER RATES.

...rage Daily			...ed by ...ies Taken.			Normal Maximum Deliveries of Meters of Several Sizes, Obtained Approximately by Graphical Methods.						
			...l Sales			Gallons. Daily.						
...rage ...ily ...ity ...nts	Gallons per Service	Gallons per ...	...1600 ...Daily.	82000	386000	5/8"	3/4"	1"	1½"	2"	3"	4"
...000	825	573				1370	1920	2850				
...000	262	234										
...000	490	309										
...000	718	354				—	1300	2950	3600	7400	18000	37000
...000	545	343										
...000	592	464										
...000	290	266										
...000	728	530										
...000	655	326										
...000	561	347										
...000	781	362				300	1150	3000	4400	7000		
...000	418	280										
...000	444	327										
...000	347	580										
...000	300	240	...1300	870	0							
...000	779	251	...1048	718	0	740		1350		10700		
...000	295	250	...187	0	0	600	800	1250	1800	8200	11000	26000
...000	524	406										
...000	467	376				500	820	1400	2100	6300	27000	
...ec.												
			...243	2130	0	750	1100	1450	2000	3000	5700	40000
...000	645	528	...1.40	12.13	0	960	1550	2300	2900	13000	19000	82000
...ec.												
...000	185	155										
...000	466	280		5.20	1.90							
...000	1590	765	...7892	6615	4226	300	1040	1850	—	4800	10000	16000
...000	725	593		5950	4660	1050	1250	2500	3000	10000	13000	
...000	250	200	0	0	0	220	1000	1300	2300	6000		
...000	489	404	0	0	0	960	1300	2400	2800	7000	8200	
...000	170	92										
...000	303	268										
...000	301											
...000	299	262										
...930	167	185										
...900	75	74	0	0	0							
...830	15766	10557	...7796	17816	9036	7750	11230	24600	24700	83400	111300	201000
	32	31	9	11	11	11	11	12	9	11	8	5
	492	341	...877	1620	825	705	1203	2050	2744	7582	13912	40200

* Port... ...mass... ...Vertical...

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CONDENSED SUMMARY OF STATISTICS ON USE AND LOSS OF WATER.

(Averaged by Systems.)

		No. of Systems Represented in Calculation of This Item.
Total number of services	524 364	35
Total number of meters	520 719	35
Average daily output, gallons	289 182 000	33
Recorded by meters, gallons	191 590 000	33
Otherwise accurately estimated, gallons	12 467 000	17
Not accounted for, gallons	59 180 000	29
Per cent. not accounted for	27.0	29
Per cent. of meters ¾ in. and over in size	13.40	34
Per cent. of meters 1 in. and over in size	3.80	32
Per cent. of meters 2 in. and over in size	1.42	32
Per cent. of meters 4 in. and over in size	0.30	32
Average size of all meters in terms of one ⅝-in. meter	1.43	34

Maximum Normal Output of One Meter.	Gal. Daily.	Cu. Ft. per Quarter.	
⅝ in.	705	8 600	11
¾ in.	1 200	15 000	11
1 in.	2 050	25 000	12
1½ in.	2 740	33 500	9
2 in.	7 580	92 000	11
3 in.	13 900	170 000	8
4 in.	40 200	490 000	5

	Per Cent. of All Takers.	Per Cent. of All Water Sold.	
Using over 82 gal. daily	61.14	89.19	12 & 9
Using over 246 gal. daily	22.82	66.08	13 & 9
Using over 820 gal. daily	4.91	44.67	14 & 10
Using over 2 460 gal. daily	1.60	37.51	13 & 9
Using over 8 200 gal. daily	0.46	27.35	16 & 11
Using over 24 600 gal. daily	0.15	19.77	14 & 9
Using over 82 000 gal. daily	0.05	16.20	16 & 11
Using over 246 000 gal. daily	0.02	8.25	15 & 11

	Per Meter.	Per ⅝-in. Meter Equivalent.	
Total output, gallons daily	492	341	32 & 31
Total sales, gallons daily	359	245	32 & 31
Not accounted for, gallons daily	130	94	29 & 28

The full table showing the detailed results here summarized is appended.

These systems had 524 364 services and 520 719 meters. The daily output, estimating roughly for three systems where sales are reported but not the total output, is about 300 million gallons, or 575 gal. per service. Of this quantity about 140 gal. per service is not accounted for.

The committee is impressed with the fact that the number of completely metered systems has greatly increased in the last few years. Apparently, also, the percentage of the total output that can be accounted for in completely metered systems has increased. Fifteen or twenty years ago an American water-works system that accounted for 60 per cent. of the total output was doing well, although in Europe, where the meter system had been earlier used and more completely developed, as much as 90 per cent. of the output had been often accounted for. The statistics now collected indicate that on an average 73 per cent. of the total output is now accounted for.

Averaging by Systems.

In general, the average for each system has been obtained, and then these averages for all systems reporting that item have been averaged.

This procedure gives the data for small systems as much weight as those for large ones. As the conditions of the business in small systems vary somewhat from those in large ones, the method tends to produce a result which better represents the smaller systems than the larger ones. The committee feels it necessary to point out this difference, although it believes that the results obtained in this way may be more generally useful than those that might be obtained by another system of averaging. For some of the items an average made up from the total figures is also given.

Many of the Reports Partial.

Only a few of the reports were filled out with reference to each item. A complete answer to the committee's questions required a reclassification of accounts, and this involved an amount of labor and perhaps also an additional expense that some of those

who replied felt could not be undertaken. This was stated to the committee in several cases, and it was, no doubt, the principal reason why returns were not received from a number of completely metered systems for which requests were made.

In making up the statistics, the returns for each item are used for every system for which they are available. The different items are, therefore, made up from data from different systems. *Because of this condition, there are apparent discrepancies in the averages. No effort will be made to harmonize these differences. The whole study is to be taken not as showing an exact average result, but rather as a compilation of representative figures that, without being precise, gives one a fair idea of some of the fundamental conditions of service as the water-works business is now carried on.*

Methods of Measuring Water.

A majority of the systems measure their total output by Venturi meters. Where pump measurement is used, there is evidence of a study of the question of slip in nearly all cases, and suitable allowances have been made. Pitometer measurements were depended upon in some cases, either directly or for checking up the pumps, and in one case the water was weired. In three gravity systems there is no record of the amount of water supplied.

Total Output.

In 32 systems reporting, the average daily output per service, averaged by systems, is 492 gal. per day. The difference between this figure and 575 gal. obtained from the gross quantities indicates the difference that may result from different methods of handling the same data, either of which considered by itself might be accepted as correct.

Total Sales.

The average amount of water sold in 32 systems amounted to 859 gal. per day per service. It is to be noted that three of the 32 systems are different ones from those used in computing total output, and the figures, therefore, are not directly comparable.

Amount of Water Not Accounted For.

The records from 29 systems, after allowing for all the water sold and measured or otherwise accurately estimated, show an amount not accounted for of 130 gal. per service daily. (This may be compared with 140 gal. obtained by considering the total quantities.)

The water not accounted for averaged 27.0 per cent. of the total output. For the several systems, water not accounted for ranges from 12 to 49 per cent. Nine systems, or nearly one third of the whole number, showed more than 80 per cent., and 4 systems, or one seventh of the whole number reporting, showed more than 85 per cent. of the water accounted for.

The amounts not accounted for per service vary from 11 gal. to 385 gal. daily. For 7 systems, or one fourth of the number reporting, the water not accounted for was less than 50 gal. per service, while for 2 systems less than 40 gal. per service is reported.

The committee considered the water not accounted for in still another way, namely, by taking in account the relative number of large meters in the different systems and proportioning the loss so that the large meters would take their share in proportion to their size. As the number of large meters in the different systems varies rather widely, this introduces another element of considerable importance into the calculation.

In carrying this out, certain ratios were assumed as representing the proportionate capacity of the larger meters. The figures used were as follows:

Size of Meter. Inches.	Relative. Capacity.
⅝	1
¾	1.67
1	3
1½	6
2	10
3	22
4	40
6	90
8	160
12	360

These ratios differ slightly for the larger sizes from those used

later for another purpose in this report. The differences do not warrant a recalculation of the data for the present use, and the results first reached are allowed to stand.

The average size of meters in each system was computed, using the numbers of meters of each size and these ratios. In this way it was found that the average size of all the meters in all the systems was 1.43; that is to say, the discharging capacity of all the meters is 43 per cent. greater than it would be if all the meters were ⅝ in. in size. In different systems the excess ranged from 1 per cent. to 121 per cent.

Dividing the loss per service for each system by the average size of meters for that system gives the average loss per ⅝-in. unit. Calculated in this way the water not accounted for amounts to 94 gal. daily for each unit, and for the several systems the range is from 11 to 174 gal. Of 28 systems, 8 show water not accounted for under 50 gal. per unit daily.

How the Water is Lost.

The water that is not accounted for is made up of various sources of loss. Included among these may be mentioned the following:

1. Leakage from the mains in the streets.
2. Leakage from the service pipes between the mains and the meters.
3. Under-registration of meters.
4. Water used for various purposes, not registered or estimated, as, for instance, water used for flushing sewers.

The committee has no means of distributing the total loss among the different sources of loss. It is the committee's belief that under-registration of meters forms a substantial part of the total loss in systems where the pipes and service pipes have been carefully and systematically followed up for leakage and where there have been no considerable uses of water for flushing sewers and similar uses without record being made of it.

As can be ascertained from the statistics which follow, meters on about half (48 per cent.) of the total number of services pass less than 100 gal. per day.

There are few meters in use at the present time that will register a steady flow of as little as 100 gal. per day.

If the amount of water now shown by that half of all meters which pass the smallest quantities of water were to pass at a uniform rate, it would all pass as leakage without moving the pistons or disks of the meters and would fail to be recorded.

It is recorded in part because that part which is recorded is drawn at higher rates, but wherever there is leakage in plumbing, so that the leak amounts to less than 100 gal. per day, more or less, according to the sensitiveness of the meter, the amount of water so lost by leakage will pass without being registered. The water that is registered probably is all drawn in, at most, one or two hours of total time, and during the remaining twenty-two or twenty-three hours of the day there will be no registration of whatever leakage there may be in the plumbing.

Some of the large-size meters will pass much larger quantities without registering.

Relative Number of Meters of Different Sizes.

On an average for all the systems, 86.6 per cent. of all the meters are of the $\frac{5}{8}$-in. size, but in a majority of systems 94 per cent. or more of all the meters are of this size. Meters 1 in. and over form 3.80 per cent. of the whole number, and those 2 in. and over are 1.42 per cent., while meters 4 in. in diameter and over are 0.30 per cent. of the total number. These are the figures averaged by systems.

The figures for the aggregate number of meters being unusually complete, it may be of interest to also record the total numbers and their distribution.

Size of Meter. Inches	Total Number of Meters in 33 Systems.	Percentage of Total Number.
$\frac{5}{8}$	432 231	84.546
$\frac{3}{4}$	57 406	11.229
1	11 378	2.225
$1\frac{1}{2}$	3 148	0.616
2	4 005	0.783
3	1 374	0.269
4	1 115	0.218
6	533	0.104
8	46	0.009
10 & 12	8	0.002
	511 240	100.000

In making up this table, a small number of $\frac{3}{8}$-in. and $\frac{1}{2}$-in. meters are included with the $\frac{5}{8}$-in. meters, and a very few $1\frac{1}{4}$-in. and other odd sizes are included with the next size smaller.

Classification of Service by the Amount of Water Drawn by Each.

This classification according to quantities of water involved a large amount of labor to those who reported to the committee, and the number of complete returns was smaller than for other items. Nevertheless the returns are sufficiently numerous to give a very good idea of the normal distribution of takers in the various classes.

In asking for this data, the committee followed the classification which it had suggested in its first report on meter rates, but carried it further by subdividing the different classes so as to show more completely the number of consumers taking different quantities of water.

In using the returns it will be convenient to refer to the quantities in gallons per service per day. All the figures in whatever unit reported have been reduced to this basis.

The lowest limit used in the classification was 82 gal. per service per day, which is equal to 1 000 cu. ft. per quarter.

It is found that (12 systems reporting) 38.86 per cent. of all the takers use less than 82 gal. per day. Almost the same number, namely, 38.32 per cent., use between 82 and 246 gal. per day. A further number, 17.91 per cent., use between 246 and 820 gal. per day, making a total of 95.09 per cent. using less than 820 gal. per day, or 10 000 cu. ft. per quarter. All these takers, ninety-five per cent. of the whole number, would come entirely under the domestic classification suggested in the committee's preliminary report.

Following the classification, 3.31 per cent. use between 820 and 2 460 gal. per day and 1.14 per cent. use between 2 460 and 8 200 gal. per day, making a total of 4.45 per cent. of all the takers that would come under the intermediate classification of the committee's preliminary report.

Of larger consumers coming under the manufacturing classification, 0.31 per cent. use from 8 200 to 24 600 gal. per day; 0.10

per cent. from 24 600 to 82 000 gal. per day; 0.83 per cent. from 82 000 to 246 000 gal. per day, and 0.02 per cent. over 246 000 gal. per day, making a total of 0.46 per cent. of the whole number of takers that would use enough water to get the manufacturing rate.

The data represented by the above brief statement have been otherwise arranged and are plotted on a diagram which is presented herewith (Plate XVI). This diagram shows the percentage of the total number of consumers taking more than various quantities of water daily, arranged in a number of different ways. A dotted line shows them averaged by the gross numbers in the systems for which the statistics were reasonably complete. A broken line shows them averaged by systems, which, as above noted, gives one small system the same relative weight in the averaging as one large one. Three other solid lines show the figures arranged in the order of size, the middle one being the medium, so selected that half the results fall below it and half above it, while the two lines marked as the normal 10 per cent. limit and the normal 90 per cent. limit are the lines which include 80 per cent. of all the results. Ten per cent. of the results fall outside of these limits on either side, representing, on the one hand, systems in which manufacturing and large users are unusually developed, and, on the other hand, small systems in which there are no such uses.

This diagram shows in compact space a more complete representation of the data than can be well given in a table.

Amounts of Water Sold to the Above Classes.

Averaged by systems (9 to 11 systems reporting), 55.32 per cent. of all the water is sold to takers coming under the domestic rate; 17.32 per cent. is sold to customers coming under the intermediate rate, and 27.35 per cent. to customers coming under the manufacturing rate.

Averaged by aggregate numbers, the distribution is different, as the larger systems supply more water relatively for manufacturing purposes. The following table gives an approximate distribution indicated by the data arranged by the total numbers

Plate XVI.
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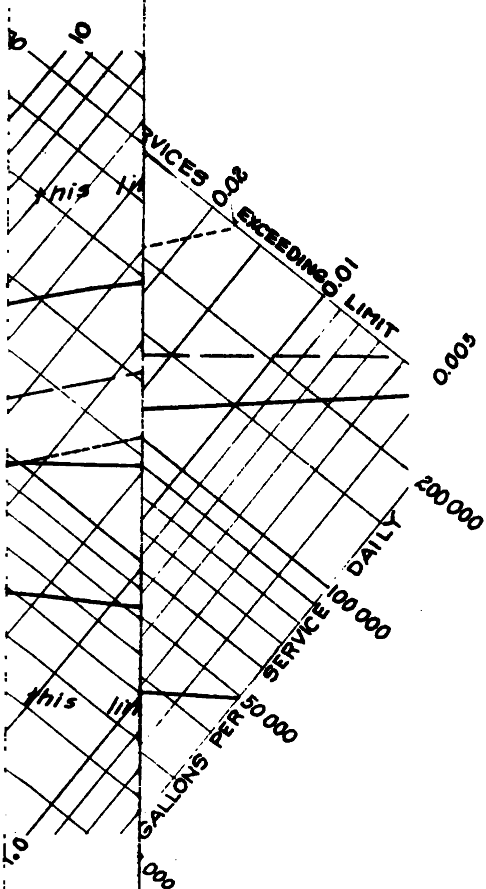

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in each class for those systems for which reasonably complete reports are available.

Range in Daily Quantities, Gal. Daily per Service.	Average Daily Quantities Sold per Service.	Per Cent. of Total Number of Services Coming in This Class.	Per Cent. of Total Output.	Total Output, Gal. per Day, from 100 Services.
0 to 82	51	29.420	3.41	1 500
82 to 246	146	47.865	15.91	7 000
246 to 820	385	16.755	14.63	6 440
820 to 2 460	1 300	3.594	10.59	4 660
2 460 to 8 200	4 070	1.807	16.64	7 320
8 200 to 24 600	12 700	0.356	10.27	4 520
24 600 to 82 000	42 300	0.071	16.37	7 200
82 000 to 246 000	120 000	0.024	6.52	2 870
Over 246 000	311 000	0.008	5.66	2 490
Total -	440	100.000	100.00	44 000

These figures are made up by approximate methods, with a few doubtful returns excluded. They are believed to represent the distribution fairly well and they check the total very well, for they show 440 gal. per service on an average sold, and adding the 140 gal. per service not accounted, which is the average from the total number, makes 580 gal. per service. This checks approximately the 575 gal. found by direct division.

Quantity of Water Delivered by Meters of Various Sizes.

The statistics collected by the committee permitted an approximate study to be made of the amounts of water delivered by meters of various sizes. This study is made by graphical methods (plotting on logarithmic paper) and is approximate. It rests on the fundamental assumption that the largest meter in any system supplies that service in the system from which most water is drawn; and that all the other services are to be assigned to the meters of the several sizes in the order of their outputs. This is not strictly correct, but for practical purposes it may not be much in error, because there are bound to be as many larger meters coming under any given limit as there are smaller meters exceed-

ing it. There will be some variations both ways, but in the aggregate these will balance.

Examined in this way, it appears that the normal maximum output for one ⅝-in. meter (data from 11 systems) is 705 gal. per day. In other words, averaged by systems there are as many ⅝-in. meters as there are services from which less than 705 gal. per day are drawn. The average output from all the ⅝-in. meters is considerably less than this. Averaged by systems, it seems to be about 116 gal. per day. The 705 gal. per day, or 8 600 cu. ft. per quarter, is the normal maximum limit for output of a meter of this size.

Different systems vary rather widely in the maximum limits for ⅝-in. meters, quantities ranging from 220 to 1 370 gal. daily being found. This difference is to be attributed principally to the divergence in practice with reference to the use of ¾-in. meters on the larger domestic services.

The classification of quantities is not available for some of the systems using the largest proportion of ¾-in. meters, and, if these statistics were available and were included, it is probable that it would lower considerably the average limit for the ⅝-in. meter probably to between 300 and 400 gal. daily. There is a similar but less marked variation at the line between the 1½-in. and the 2-in. meters.

In a similar way, the average maximum outputs for other sizes of meters are as follows:

Size of Meter. Inches.	Normal Maximum Output. Gal. per Day	Corresponding Number of Cubic Feet per Quarter.
⅝	705	8 600
¾	1 200	15 000
1	2 050	25 000
1½	2 740	33 500
2	7 580	93 000
3	13 900	170 000
4	40 200	490 000

The detailed figures show considerable divergence of practice with reference to the amounts of water that meters of all sizes will handle, but the divergence with respect to the line of division between ⅝-in. and ¾-in. meters is much greater than else-

where, and the committee suggests that an interesting and profitable subject for discussion by the Association would be the question as to whether it is better to use a ⅝-in. meter or a ¾-in. meter for services drawing from 300 to 1 000 gal. per day. Such a discussion would tend to establish the principles that should govern, and it might aid in reaching a more logical and scientific method of determining the size of meters required for various services.

It is, of course, true that services are occasionally found which require water at a certain rate, and where that rate determines the size of meter even though the total aggregate draft is small, but it would seem as though, generally speaking, some relation between the normal rate of draft and the size of meter in the larger domestic services might be found.

The distribution of the whole output among meters of different sizes, estimated by the aid of graphical and roughly approximate methods (subdividing as a matter of interest the ⅝-in. meters into four divisions) is shown by the following table:

Size of Meter. Inches.	Per Cent. of Total Number of Services.	Mean Quantity per Meter. Gallons per Day.	Total Quantity 100 Services. Gallons Daily.	Per Cent. of Total Quantity of Water Sold.
⅝ a	25	50	1 250	2.84
⅝ b	25	90	2 250	5.11
⅝ c	25	150	3 750	8.52
⅝ d	9.546	275	2 620	5.91
Total ⅝	84.546	116	9 870	22.38
¾	11.228	580	6 500	14.82
1	2.225	1 700	3 780	8.59
1½	0.616	2 380	1 470	3.34
2	0.783	5 500	4 300	9.77
3	0.369	10 000	3 690	8.39
4	0.218	20 000	4 360	9.91
6	0.104	70 000	7 280	16.55
Larger	0.011	250 000	2 750	6.25
	100.	440	44 000	100.

In this connection, a table from the New Orleans annual reports for the years 1913 and 1914, George G. Earl, general superin-

tendent, shows the average daily drafts of water by meter sizes as follows:

Size of Meter. Inches.	Average Draft per Service. Gal. per Day. 1913.	1914.
$\frac{5}{8}$	148	162
$\frac{3}{4}$	370	410
1	1 120	1 100
$1\frac{1}{2}$	2 400	3 100
2	6 100	6 500
3	......	33 800
4	......	8 350
6	......	9 850
8	......	45 700

This record is unique and most interesting. It is comparable with the average results deduced by the committee from the statistics furnished to it. The committee suggests that others might find it advantageous to follow this method of keeping track of sales classified by meter sizes. With books arranged for that purpose, it would not appear that the additional labor involved would be great.

Conclusions.

The committee concludes that with present American conditions, with a pipe system that has been carefully watched for leaks and made as tight as it is reasonably practical to make it, with complete metering and with meters carefully tested and kept in order in accordance with the best current practice, one may reasonably hope at the present time to reduce the unaccounted-for water to 20 per cent. of the total output, or to from 60 to 80 gal. per service daily. Some systems that are well managed fall short of these standards, and occasionally more favorable conditions may be reached and still lower figures obtained.

Better systems of testing old pipes in streets and service pipes between the street mains and the meters, a raising of the standard of efficiency of small meters at low rates of flow, the use of compound meters or other improved devices for making certain the registration of low flows through the larger meters, and estimating carefully by the best available means the amounts of water drawn for all uses where measurement by meter is not possible,

will all tend to increase the amount of water that can be accounted for.

Information as to the normal distribution of business between large and small takers and of the normal range of output for various meter sizes, made available by the statistics presented, should be helpful in discussing the question of meter rates and their classification and especially in fixing fair service charges for meters of the larger sizes.

Service Charges for Large Meters.

Considerable interest in this subject is indicated by the inquiries that have come to the committee in regard to it. It is the committee's view that the service charge for all meters, like the price per 1 000 gal. of water, should be left to local judgment and should be fixed in accordance with local conditions, and that the committee should make no invariable recommendation in regard to it.

The committee has already made, in its preliminary report, a suggestion with regard to the service charge for $\frac{5}{8}$-in. meters, and a like suggestion in regard to the service charges for larger meters coming from this committee may be helpful to many members.

The following study is made as to fair charges for larger meters.

Service charges for large meters should be based in a general way upon their carrying capacity. The carrying capacities of different meters of the same size vary greatly, and it is no easy matter to get a general basis that will be sufficiently accurate at all points. The committee considers in a general way that a 2-in. meter is equivalent in discharging capacity to ten $\frac{5}{8}$-in. meters, and it takes a 2-in. meter as the starting point for the discussion.

Comparison may be made on the basis of areas, that is, by the squares of the diameters. In the case of larger meters, this is nearly accurate. In the case of smaller ones, the diameters used to designate the meters are understood to be nominal and may differ somewhat from the exact figures. Nevertheless, the areas computed from these diameters do give something of an idea of the relative capacities.

The relative carrying capacities of disk meters at a fixed loss of head, as given in the American Civil Engineers' Pocketbook

page 967, may be used. It is, of course, understood that different makes of meters vary a good deal in their capacities. The figures mentioned were compiled by the chairman of this committee, some years ago, after receiving returns from various manufacturers of meters and examining records of experiments by a number of members of the Association, and they were selected as being representative of the different sizes. Round figures were used, and they are to be taken as a general indication only.

The maximum normal amount of water supplied by each size, as deduced by this committee from the returns made to it in the inquiry with reference to waste prevention, may also be used. The figures obtained in this way represent only a limited amount of data, but that is the best of its kind now available to the committee. There are some irregularities in the scale. For instance, 2-in. and 4-in. meters are distinctly more popular and are used in larger relative numbers than some of the intermediate sizes, and in fixing the normal capacity of meters the influence of the tendency must be discounted to reach the fair relative capacities.

The relative capacities of meters of several sizes calculated in each of these three ways, taking the capacity of a 2-in. meter as ten in each case, are as follows:

Size of Meter. Inches.	Ratio of Areas.	Ratio of Carrying Capacities of Disk Meters at Fixed Loss of Head.	Ratio of Maximum Normal Outputs Indicated by Committee's Statistics.	Ratio Used for This Discussion.
5/8	0.98	1.14	0.93	1.0
3/4	1.41	1.85	1.59	1.7
1	2.50	3.20	2.71	3
1½	5.62	6.25	3.60	6
2	10.00	10.00	10.00	10
3	22.50	20.80	18.40	20
4	40.00	35.00	53.00	30
6	90.00	62.50		60

Service Charges Deduced from These Ratios.

In the preliminary report of this committee, of September 9, 1914,* it was suggested "that the service charge for a 5/8-in. meter would be made up of three parts, namely, —

* Journal N. E. W. W. A., XXVIII, 199.

"First, 10 per cent. of the average investment of the works in the service pipe and meter.

"Second, $1 per annum for reading meters, billing, and collecting.

"Third, $2 per annum for the probable value of unregistered water.

"For a domestic service charge with ⅝-in. meter, the ordinary service charge may properly be $3 when the service and meter are paid for by the taker; $4 when the meter is furnished by the works; and $5 or $6 where both meter and service pipe are paid for by the works; the lower figure being used where the average cost of the service pipe is under $15 and the higher where it is greater than $15."

The item in this calculation for a large meter corresponding to the $2 per annum in the above schedule, "for the probable value of unregistered water," must also cover any cost to the system that there may be in the extension of mains and other facilities that will be necessary in connection with the use of large service connections, and any value that there may be to the taker in having large quantities of water available instantly for any purpose.

With reference to the amount of water under-registered by large meters, it is interesting to note that in the experiments made by F. C. Kimball, at Knoxville, presented to this Association on September 10, 1903,* that of nine 6-in. meters furnished by their makers for test, only three were able to register a flow of 4 500 gal. per day. In other words, in a majority of new 6-in. meters, 4 500 gal. per day would pass entirely without registration. At 10 cents per thousand gallons, such an amount of leakage continuously for a year amounts to $164; and if, on an average of 6-in. meters, the leakage amounts to one half this quantity, it amounts to $82 per annum.

The possibility of loss of this quantity of water, and in some cases of a much greater quantity, is not to be taken as the sole ground for the service charge. Nevertheless, the facts that such losses are possible; that such losses do exist in many or most services; that the works have to furnish the water that is so lost;

*JOURNAL N. E. W. W. A., XVII, p. 305

that water costs money, and that the value of the water lost must be made up in some way, are among the substantial elements that must be considered in arriving at an equitable service charge.

Following the matter further, the service charges for larger meters are reached as follows:

Size of Meter. Inches.	Relative Capacity.	$2 per Unit of Capacity.	Service Charge, being $2 per Unit of Capacity with $1 Added.	Round Figure to be Used.
5/8	$1	$2	$3	$3
3/4	1.7	3.40	4.40	5
1	3	6	7	7
1 1/2	6	12	13	12
2	10	20	21	20
3	20	40	41	40
4	30	60	61	60
6	60	120	121	120

It is interesting to see how much per thousand gallons the application of these service charges would amount to for quantities of water that may be taken as the normal outputs for meters of the different sizes.

Taking annual quantities and smoothing the figures a little, by taking into account both the actual performance as indicated by the committee's returns and the possible performance as indicated by the relative capacities of the meters, we have the following tabular statement:

Size of Meter. Inches.	Service Charge.	Greatest Normal Quantity per Annum. Thousands of Gallons.	Least Normal Quantity per Annum. Thousands of Gallons.	Service Charge in Cents per Thousand Gal. for Greatest Normal Quantity.	Service Charge in Cents per Thousand Gal. for Least Normal Quantity.
5/8	$3	300	0	1.00	—
3/4	5	500	300	1.00	1.67
1	7	900	500	0.78	1.40
1 1/2	12	1 800	900	0.67	1.33
2	20	3 000	1 800	0.67	1.11
3	40	6 000	3 000	0.67	1.33
4	60	9 000	6 000	0.67	1.00
6	120	18 000	9 000	0.67	1.33

This indicates that, for the ⅝-in. meter on the largest services normally handled by meters of this size, the service charge will amount to 1 cent per 1 000 gal. With one sixth of this amount passing, which perhaps approximately represents the average work of a ⅝-in. meter, the service charge is equivalent to about 6 cents per 1 000 gal. The table shows the corresponding figures for all the sizes. For the larger meters the service charge ranges from ⅔ of a cent per 1 000 gal. for meters working to the ordinary limit of their capacity, increasing to an average of about 1⅓ cents per 1 000 gal. for meters passing the smallest normal quantity, which is taken as equal to the greatest normal quantity handled by a meter of the next smaller size. In other words, in a general way for manufacturing meters the service charges adjusted in this way would vary between ⅔ of a cent and 1⅓ cents and probably would average about 1 cent per 1 000 gal. for meters working at normal capacity.

In connection therewith, a manufacturing rate would naturally be selected about 1 cent per 1 000 gal. less than would be used if these service charges were not to be collected.

With this procedure followed, the water works could always let the taker select the size of meter. If the taker selected a large one, the works would be insured of a return for it commensurate with its cost and with the probable general cost of supplying the extra mains and connections required in connection therewith and of standing the extra losses of water by leakage and under-registration that also must be anticipated. In other words, the water-works plant would have no objection to the installation of large meters in any number if the takers were willing to pay for them. This the committee believes is a logical condition for the best interests of the business. It can only be secured by the use of an adequate service charge.

If any taker has a meter which is worked to the limit of its capacity, that is to say, one that is supplying more than the ordinary maximum assumed for that size of meter, the effect would be that such a taker would get automatically a small discount on his bill, because the service charge for that meter would be applied to the larger quantity of water drawn through it. On the other hand, if a meter considerably larger than needed,

or than is usual for the quantity drawn, were used, the service charge would amount to more per 1 000 gal. than the normal amount and the taker would be paying something extra for the extra capacity required and furnished to him by the works.

The use of such service charges would tend to discourage the use of unnecessarily large service connections and meters, and this is a desirable condition. On the other hand, with a one cent reduction in the manufacturing rates, there is no increase in bills in case of a normally busy meter.

The committee suggests further that the service charge always be reckoned on the size of meter and not on the size of service pipe, thus giving an opportunity to one who has put in a meter that is too large to substitute a smaller one and get the benefit of the smaller service charge without having to change his service pipe. This arrangement also permits the use of a larger service pipe than is needed to anticipate reduction of carrying capacity by corrosion through a long term of years, without requiring the use of an unnecessarily large meter, with payment therefor.

The figures above mentioned in no case include 10 per cent. of the cost of the service and meter as far as paid for by the works and included by the committee as part of the service charge on $\frac{5}{8}$-in. meters, and this allowance should be added wherever the customer does not pay the first cost of the service and meter.

Conclusion.

Your committee, after considering the further discussions by members of the Association, renews its recommendation that the Association adopt the form of meter rate schedule presented to it by your committee, and printed on page 361 of the Journal of this year, as a standard form of rate for gradual adoption as meter rates are revised and when new rates are to be made.

This schedule is drawn in terms so broad that it covers both the uniform rate for all quantities as now used by a few systems and the sliding scale which is in much more general use.

Its principal advantage is that it simplifies and standardizes the sliding scale and also the question of whether a minimum rate or a service charge shall be used and the question of how the

amount shall be determined and applied, but it does this in a way that permits the uniform rate to be used where it is preferred.

The committee believes that this form of schedule provides all needed flexibility for present water-works conditions and that it will do away with many unjust discriminations contained in existing schedules of meter rates, and that its adoption will facilitate comparison between rates in different systems.

The committee believes that it has now completed all the work that it has been asked to undertake, and it requests that it be discharged.

Respectfully,

ALLEN HAZEN, *Chairman,*
A. W. CUDDEBACK,
A. E. BLACKMER,
JAMES L. TIGHE,
CHARLES R. BETTES,
PHILANDER BETTS,
Committee on Meter Rates.

DISCUSSION.

MR. ALLEN HAZEN.* Perhaps I may say a few words in regard to this schedule,† the adoption of which is recommended by your committee. The discussions that have taken place show that there has been some misunderstanding in regard to what it proposes, although I think a reading of the preliminary report and the final report would clear these up.

This proposed schedule does not fix meter rates. It simply fixes a form and leaves the rates to be written in, larger or smaller as local conditions require. The form of the schedule permits the sliding scale, but does not require it. It is broad enough to cover either a uniform rate or the sliding scale. At the present time I suppose nine tenths of all the water-works systems in the country use the sliding scale; but the sliding scale as now used is tremendously varying. There are almost as many forms of it as there are water-works systems. The committee believed that one simple standard form would answer just as well and a great

* Of Hazen, Whipple and Fuller, New York.
† XXX, 361. Presented February 9, 1916.

deal better than these endless variations, and the form suggested is the one which the committee believes will be most generally serviceable.

Adopting this form of schedule, then, means standardizing the sliding scale and standardizing it in such a way that one who prefers the uniform rate can use it.

And in connection therewith the committee has made recommendations in regard to service charges, although the amounts of the service charges that have been suggested by the committee are not part of the form of schedule that is recommended for adoption. The committee thinks that these amounts should not be adopted, but, like meter rates, should be left open for discussion in individual cases. The committee hopes its suggestions will be helpful, but it does not want to make them binding on any one.

Now, a good deal of the discussion of the committee's report related to the relative merits of the uniform rate and the sliding scale. That was a matter which the committee did not report upon. The form of rate schedule proposed by the committee is broad enough to cover both kinds of rates. There are many members of the Association who believe that the uniform rate is the logical form for use, and they may be right. I was disposed myself some time ago to think that a uniform rate in connection with adequate service charges would be fairest, but further study of the question has shaken my confidence in that earlier conclusion.

The whole cost of supplying water may be divided into three parts. There are various ways of classifying it, but I suggest for your attention this division. The annual cost may be most conveniently considered.

First, the cost of supplying water, including all the costs that there are up to the point when the water is delivered under pressure at a reasonably central point. This includes interest (or a proportional part of the net profits) on the whole investment or worth of the supply works and of the land held for use in connection with the supply; the depreciation on those works; all operating expenses, and a pro-rata division of general expenses of all kinds that cannot otherwise be assigned to a part of the service.

Second, the cost of distribution, including all the costs that there are for pipes in the streets and distributing reservoirs, and

the care of the pipes and the work that is done to prevent and stop leakage, and the value of whatever water may be lost as leakage from the pipes in the streets.

Third, the service cost, including the costs of service pipes and meters as far as they are borne by the water-works department, and all the costs of reading meters, billing, collecting, and general office expenses, and the value of whatever water may be lost as leakage or as under-registration of meters.

The whole annual cost of supplying water may be divided into these three parts, and the division may be made complete by dividing, pro-rata, taxes, salaries of general officers, etc., so that every cent of the gross income is assigned to one of the three parts.

Now, then, the cost of the water per thousand gallons is the cost of water under the first heading divided by the total annual output, and this cost is the first part of the meter rate. That ought absolutely to go with every gallon of water that is supplied, and it ought to be uniform to every one, whether a person takes one gallon or a million.

To drop for a moment our logical order, the service costs in the third heading can best be assessed on the takers as service charges. They can be and often are carried in other ways; that is to say, they can be loaded as a price per thousand gallons on the water sold, but the simplest and fairest way is to have all the service costs assessed on the services in proportion to their sizes, and that is what the committee thinks should be done.

We have left for disposal the distribution cost under the second heading. A part of the distribution cost is the fire service cost. Most of the fire service cost is included in the distribution cost. Most water-works systems receive some revenue for fire protection; most of them receive very much less for fire protection than the fire protection is really worth. The difference — that is, the excess in fair value over actual collections — has to be carried by the water rates. This unpaid part of the cost of fire service has to be paid by the water-takers in some form. They also must bear all the other costs of distribution. When actual receipts for fire service are taken out, all the rest of the cost of distribution of the water has to be carried by the water rates in some way. The money must be raised. Now, how is it going to be done?

Some people have thought that the distribution cost should be added to the service charge. There is a good deal to be said in favor of that view. That view has been reflected in the Wisconsin Commission's decisions, and in the writings of some people who have studied the matter closely. As far as the larger services are concerned, I think, perhaps, that is as good a way as could be adopted. But the rub comes with the ⅝-in. meters. Ninety per cent., more or less, of all services are through ⅝-in. meters, and a service charge adjusted to the size of the meter is absolutely uniform for 90 per cent. of all the takers. Now, the 90 per cent. of the takers who use ⅝-in. meters do not represent by any means uniform conditions; they represent quite the reverse. There is the greatest diversity of conditions among those consumers. And if the whole of the load of the distribution cost is added to the service charges on meters, and all ⅝-in. meters carry the same load, it means that the smallest takers, the smallest houses, are assessed to a point that it isn't wise to attempt to assess them and to a point that the business won't stand. As a practical proposition, gentlemen, you can't do it. The service charge cannot be loaded in that way, and the reason for it is that 90 per cent. of your services are through the same size of meters. There isn't any reason for splitting up this 90 per cent. of the meters into different sizes, and the committee does not know of any ready way by which those services can be classified and different service charges applied to some of them from those that are used for others. So loading the whole distribution cost on the service charges practically cannot be done.

Now, another way is to load it all on the price of the water. If we divide the whole cost of distribution by the whole quantity of water that is sold, we have the average total unit cost of distribution that can be added to the cost of the water. That can be done. That results in the uniform rate, and if it is desired, that is all right. But looking at it as a matter of cost to the works, the average industrial service, as the committee finds from these statistics, takes 30 000 gal. of water per day. The average domestic service takes just over 100 gal. per day. Anybody knows that it costs more per 1 000 gal. to handle two or three hundred domestic services with two for three miles additional street pipe than it

does to serve one manufacturing establishment. From the standpoint of cost of service, from the standpoint of ordinary business methods, an industrial service, taking an average of 30 000 gal. per day, naturally would get, and under American practice in nine cases out of ten does get, a lower rate per 1 000 gal. than a domestic consumer taking only 100 gal. per day. It is cheaper relatively to maintain the service of the large taker, and all the conditions of business, and nearly all the precedents, are in favor of that arrangement. If the uniform rate is adopted, the manufacturer is loaded to pay for the deficiency in revenue on the small services. That can be done. No system of water rates will distribute the load just where it ought to go, and it may be that the inequalities that grow out of the uniform rate are not so great that they cannot be tolerated.

But the other point of view is that, because of the well-known greater cost of service in supplying the small customers, this load is not to be distributed on all the water evenly, but instead it is to be distributed unevenly, putting some of it on all of the water and more of it on the water drawn by smaller services and on those that are intermediate in size.

That, gentlemen, results in the sliding scale. Perhaps it does not all work out in a way that you will think is ideal; there may be objections to it, but I am inclined to think, from the standpoint of the cost of the service and from the standpoint of the value of the service to the takers, that perhaps a scale with a moderate amount of slide in it comes nearer to doing even-handed justice between all the classes of consumers than anything else which can be suggested at this time.

Most of the arguments that have been presented to this Association and to this committee against the sliding scale have been directed against scales with excessive amounts of slide; and I think they are absolutely sound when used in that way. That is to say, scales that slide so much that the manufacturer gets water for a fifth or a tenth of the price per 1 000 gal. that is paid by the domestic consumer cannot be defended in this year 1916. They may have grown out of conditions that existed many years ago when the water-works business was young, and they may have been justified by earlier conditions. I think as a matter of fact

that they are mostly inheritances that have come down from earlier times, and whether or not they were right when they were adopted does not much concern us now. But at the present time such rates cannot be justified. They are discriminatory, and the arguments which have been presented against the sliding scale, as far as they relate to scales with such a great amount of slide, are absolutely sound, and the committee agrees fully that such excessive slides ought not to be permitted.

The committee did not think it was its function to determine absolutely the amount of slide in the scale, but it did express to the Association in no uncertain terms that it thought the amount of slide should very rarely exceed a 2-to-1 ratio.

That, gentlemen, is what the committee has tried to do in this report which is before you, and I want to add that this form of rates which has been recommended to the Association has already been adopted by the Hackensack Water Company, a company supplying water in the suburbs of New York to some 300 000 people more or less. That has been brought about largely by one member of our committee; and I understand from Mr. Sherman that it has also been adopted at Middletown, Conn., and it is also under consideration in a number of places where the question of rates is up at the present time. It isn't the committee's idea that adopting this schedule commits any one to it, or that any rates will be revised sooner than they otherwise would be. It simply sets up a standard to work to whenever the question of rate revision is up in your respective systems, and we hope that having such a standard which will be gradually worked to will result ultimately in working out and eliminating the erratic variations in rate schedules which exist at the present time and will put the whole business on a more rational and satisfactory basis.

(It was voted to accept the reports of the Committee on Meter Rates, and adopt the recommendations, and the committee was discharged.)

PROCEEDINGS.

THIRTY-FIFTH ANNUAL CONVENTION.

PORTLAND, ME.,
September 13, 14, and 15, 1916.

The thirty-fifth annual convention of the New England Water Works Association was held in Portland, Me., September 13, 14, and 15, 1916, the official headquarters of the Association being at the City Hall, where the sessions of the convention were held and the Associate members displayed their exhibits.

Following is a list of the members and guests in attendance:

HONORARY MEMBERS.

E. C. Brooks.
R. C. P. Coggeshall.
Desmond FitzGerald.
A. S. Glover.
F. E. Hall.
F. W. Shepperd.
G. A. Stacy.
R. J. Thomas. — 8.

MEMBERS.

G. H. Abbott.
J. W. Ackerman.
S. A. Agnew.
W. W. Albee.
F. E. Appleton.
F. L. Andrews.
James Aston.
F. S. Bailey.
M. N. Baker.
L. M. Bancroft.
F. A. Barbour.
H. K. Barrows.
G. W. Batchelder.
G. H. Bean.
F. D. Berry.
F. E. Bisbee.
H. W. Bishop.
C. M. Blair.
G. W. Booth.
George Bowers.
C. L. Bowker.
Bertram Brewer.
A. W. F. Brown.
Alvin Bugbee.
A. N. Burnie.
James Burnie.
L. W. Burt.
John Byrne.
J. M. Caird.
C. J. Callahan.
C. E. Chandler.
J. C. Chase.
J. H. Child.
E. S. Cole.
F. L. Cole.
W. R. Conard.
J. E. Conley.
V. R. Connor.
H. J. Cook.
H. R. Cooper.
G. K. Crandall.
H. C. Crowell.
John Cullen.
F. L. Cushing.
F. A. Darling.
F. J. Davis.
J. M. Diven.
A. O. Doane.
J. S. Dunwoody.
J. A. Durst.
C. H. Eglee.
E. D. Eldredge.
J. F. Ellis.
G. C. Emerson.
S. F. Ferguson.
G. H. Finneran.
R. J. Flinn.
F. L. Fuller.
M. S. Fuller.
W. E. Fuller.
W. S. Garde.
Patrick Gear.
H. T. Gidley.

T. C. Gleason.
H. J. Goodale.
W. M. Gooding.
F. W. Gow.
J. W. Graham.
S. M. Gray.
P. T. Gray.
Thomas Grieve.
A. S. Hall.
C. R. Harris.
A. F. Hart.
J. W. Hartigan.
L. M. Hastings.
W. C. Hawley.
D. A. Heffernan.
Edgar Hodges.
C. D. Howard.
A. C. Howes.
W. F. Howland.
E. W. Humphreys.
C. E. Johnson.
W. S. Johnson.
Willard Kent.
J. A. Kienle.
J. F. Kidder.
S. E. Killam.
A. C. King.
G. A. King.
John Knickerbacker.
Morris Knowles.
B. C. Little.
J. B. Longley.
W. J. Lumbert.
P. J. Lucey.
C. E. McDonald.
S. H. McKenzie.
W. A. McKenzie.
Hugh McLean.
W. H. McMahon.
H. V. Macksey.
A. E. Martin.
T. P. Martin.
John Mayo.
J. H. Mendell.
F. E. Merrill.
G. F. Merrill.
M. L. Miller.
A. R. Murphy.
J. W. Murphy.
W. G. Newhall.
R. J. Newsom.
John Parsons.
E. L. Peene.
C. E. Peirce.
H. E. Perry.
A. E. Pickup.
E. D. Pride.
E. W. Quinn.
J. H. Ranger.
J. F. Reagan, Jr.
A. A. Reimer.
J. H. Remick.
J. L. Rice.
L. C. Robinson.
J. A. Rourke.
P. R. Sanders.
H. W. Sanderson.
C. M. Saville.
J. B. Sando.
A. L. Sawyer.
W. P. Schwabe.
G. G. Shedd.
J. E. Sheldon.
C. W. Sherman.
H. L. Sherman.
H. H. Sinclair.
M. A. Sinclair.
G. Z. Smith.
G. H. Snell.
H. T. Sparks.
G. T. Staples.
O. H. Starkweather.
E. L. Stone.
W. F. Sullivan.
C. N. Taylor.
A. T. Thompson.
Milton Thorne.
J. L. Tighe.
J. A. Tilden.
A. H. Tillson.
R. K. Tomlin, Jr.
D. N. Tower.
C. H. Tuttle.
Lincoln Van Gilder.
L. L. Wadsworth.
J. H. Walsh.
C. L. Warde.
G. F. West.
N. M. West.
V. F. West.
R. S. Weston.
W. J. Wetherbee.
J. G. Whitman.
R. W. Wigmore.
E. K. Wilson.
F. J. Wise.
I. S. Wood.
L. C. Wright. — 171.

Associates.

Addressograph Co., A. L. Davis, H. B. Phillips.
Allen & Reid, Inc., Z. M. Jenks.
The American City, E. J. Buttenheim.
American Manganese Bronze Co., T. H. Addie, F. H. Linthicum.
W. L. Blake Co., W. L. Blake, D. H. Miles.
Harold L. Bond Co., F. M. Bates, C. R. Pollard.
Builders Iron Foundry, F. N. Connet, N. L. Sammis.
A. M. Byers Co., H. L. Fiske, J. J.

Kiley, A. M. McCormack, G. F. Uhler.

Carbic Mfg. Co., S. K. Ferris.

Central Foundry Co., R. W. Conrow, W. H. Feltt.

Chapman Valve Mfg. Co., W. R. Atchinson, V. N. Benglet, J. J. Hartigan, Thomas Maher, C. E. Pratt, H. U. Storrs.

Chicago Pneumatic Tool Co., A. M. Baker, F. S. Eggleston, Jr.

Darling Pump & Mfg. Co., H. A. Snyder.

Joseph Dixon Crucible Co., G. W. Hart, H. A. Nealley.

Eddy Valve Co., H. A. Holmes, H. R. Prescott.

Electro Bleaching Gas Co., E. D. Kingsley.

Engineering and Contracting, A. L. Marsh.

Engineering News, William Buxman.

Engineering Record, I. S. Holbrook.

Ford Meter Box Co., E. H. Ford, T. W. McNannee.

Garlock Packing Co., C. D. Allen, W. C. Marshall.

C. Godfrey.

The Goulds Mfg. Co., C. W. Fulton, L. Loewe.

The Hartford Contractors Supply Co., K. B. Noble.

F. H. Hayes Machinery Co., F. H. Hayes.

Hays Mfg. Co., C. E. Mueller, F. T. Myers.

James Hermiston Mfg. Co., G. H. Howard.

Hersey Mfg. Co., W. A. Hersey, W. T. Kershaw, J. H. Smith.

Kennedy Valve Co., M. J. Brosnan.

The Leadite Co., G. W. McKay, Jr., J. P. McKay.

Lead Lined Iron Pipe Co., F. H. DuBois, T. E. Dwyer.

Ludlow Valve Mfg. Co., A. R. Taylor.

Macbee Cement Lined Pipe Co., J. D. MacBride.

H. Mueller Mfg. Co., G. A. Caldwell, J. B. Clark, H. S. Tracy.

Multiplex Mfg. Co., J. F. Casey.

National Meter Co., J. G. Lufkin, H. L. Weston.

National Tube Co., H. T. Miller, F. N. Speller.

National Water Main Cleaning Co., B. B. Hodgman.

Neptune Meter Co., H. H. Kinsey, R. D. Wertz.

The Pitometer Co., E. D. Case.

Pittsburgh Meter Co., B. E. Arnold, J. W. Turner.

Rensselaer Valve Co., C. L. Brown, J. S. Warde, Jr.

Ross Valve Mfg. Co., William Ross.

S. E. T. Valve and Hydrant Co., C. L. Lincoln.

Simplex Valve & Meter Co., G. W. Stetson.

A. P. Smith Mfg. Co., F. L. Northrop, A. C. Neiman.

The Smith & Abbott Co., J. H. Douglas, W. H. Goodwin, E. F. Hayden, R. C. Parker, S. F. Seavey.

Standard Cast Iron Pipe & Foundry Co., W. S. Setti, J. C. Atwell, S. D. Higley, H. F. Hoyt.

Union Water Meter Co., D. K. Otis, E. K. Otis.

United Brass Mfg. Co., H. A. Hagdowy, J. A. Sharp.

United States Cast Iron Pipe & Foundry Co., E. B. Grubb.

Wallace & Tiernan, Inc., M. F. Tiernan.

Warren Foundry & Machine Co., A. J. Girard, J. H. Morrison.

Water Works Equipment Co., W. H.

Van Winkle, Jr., W. H. Van Winkle.

R. D. Wood & Co., H. M. Simons, C. R. Wood.

Henry R. Worthington, W. F. Bird, Samuel Harrison, E. P. Howard, A. M. Pierce, H. F. Peake. — 107.

Guests.

Maine.

Auburn, Mr. & Mrs. Andrew P. Cobb, Fred Gordon, John J. Lawler.

Augusta, Mrs. W. W. Albee, Mrs. Bradbury, Paul L. Bean, George C. Danforth, Miss Mary L. Doe, R. F. Leach, Robert M. Moore, F. J. McArdle, Ralph A. Parkers, Robert Morong.

Bangor, Charles W. Mullen.

Biddeford, Miss Helen M. Burnie, B. F. Cleaves.

Brunswick, Robert J. McDonald, Daniel W. Scribner, Edward W. Wheeler.

Cumberland Mills, W. E. Ferry, C. W. Mullen.

Gardiner, Mr. & Mrs. L. C. Ballard, S. D. Soule.

Houlton, B. B. McIntyre.

Kezar Falls, Allen Garner.

Lewiston, Ellen Callahan, Gertrude Callahan, T. W. Kerrigan, Louis Trial, Mrs. J. B. Longley.

Mechanics Falls, A. C. Frank.

Pittsfield, A. H. Burse.

Portland, Miss N. M. Alvord, George S. Beal, W. L. Blake, E. O. Boothby, Wilford G. Chapman, A. E. Clark, Harold B. Cole, Philip T. Conley, Mr. & Mrs. James W. Coburn, A. L. T. Cummings, John J. Devine, Mr. & Mrs. Edward Duddy, Eulalie Duddy, Harry A. Fuller, Mrs. P. Y. Gray, L. B. Griffin, Mrs. Donald Gardner, Mrs. C. R. Harris, E. C. Hersey, Mrs. Holmesburg, J. Arthur Jackson, Wilmot G. Jackson, Miss Kathleen Jarrett, William E. Jeffords, H. I. Jordan, Loring M. McKenney, George S. Merrill, Mr. & Mrs. W. B. Moore, Miss Florence Mosher, Daniel E. Moulton, P. H. Buswell, Miss Barbara W. Nelson, Mrs. S. H. Noyes, Frank O'Laughlin, Mr. & Mrs. E. L. Parrott, F. J. Perry, Rear-Admiral Robert E. Peary, E. E. Rogers, George R. Rooney, W. D. Sears, Harold F. Schnurle, Thomas Tetreau, M.D., Mrs. Milton Thorne, Winslow E. Townsend, Mr. & Mrs. Frank S. Wallace, Mrs. North M. West, Mrs. G. F. West, Mrs. Vernon F. West, Mrs. A. M. Pierce, James H. Heald.

Rumford, Miss Mabel Chase, H. L. Elliott, C. S. Osgood.

Sanford, Mrs. F. L. Andrews, Miss Marion Andrews.

Sebago, L. J. Johnson, William Johnson.

South Portland, Mr. & Mrs. Albert D. Boyd, Fred C. Boyd, Miss Lilly Kramer.

Waterville, Mrs. B. Brown, Mr. & Mrs. H. D. Eaton.

Westbrook, Joseph E. Perry.

Yarmouth, John A. Seabury, Miss Ada B. Seabury.

New Hampshire.

Berlin, Mr. & Mrs. C. C. Gerrish, Mrs. W. M. Gooding.

Derry, Mrs. G. H. Bean.

Manchester, Mrs. J. H. Mendell, L. H. Shattuck.

Somersworth, Mrs. John Parsons.

VERMONT.

Burlington, Julia Simays.

MASSACHUSETTS.

Andover, Mrs. Lottie M. Cole, Mrs. E. M. Weeks, F. E. Smith.

Arlington Heights, Mrs. J. D. MacBride.

Attleboro, Mrs. H. J. Goodale, Carrie L. Perry, Mr. & Mrs. H. A. Smith, Mrs. G. H. Snell.

Boston, Mrs. F. M. Bates, Miss Pearl L. Bates, Mrs. G. A. Caldwell, Mrs. A. L. Davis, Mrs. G. C. Emerson, F. J. Foley, D. L. Furners, E. G. Facy, Mrs. R. J. Flinn, Elizabeth R. Flinn, C. F. Glavin, J. M. Griffeth, Mrs. William S. Johnson, Mrs. A. S. Glover, Mrs. H. H. Kinsey, Joan M. Ham, Mrs. L. W. Richardson, J. J. Riley, Mrs. E. W. Shedd, Ellsworth N. Smith, Lester W. Tilden, Mrs. R. D. Wertz.

Bridgewater, Mrs. John Mayo, Miss Sarah W. Mayo.

Brookline, John Jackson.

Cambridge, Mrs. L. M. Hastings, T. J. Mulvahill, Patrick T. Mullin.

Chelmsford, Mrs. Walter McMahon.

Chicopee, William O'Brien, John Sullivan.

Cohasset, Mrs. D. N. Tower.

Dedham, Miss Grace M. Staples.

Fitchburg, Mrs. A. W. F. Brown.

Framingham, Annie G. Howland.

Franklin, Cathleen Darling.

Gardner, F. W. Dinwiddie.

Greenfield, Mr. & Mrs. W. T. Noyes, Mrs. G. F. Merrill.

Groton, A. A. Wood.

Haverhill, N. S. Foote.

Holyoke, Martha McLean, Mrs. Hugh McLean, Marion McLean, Mrs. J. F. Ranger, Madeline Sheldon, Mrs. J. E. Sheldon.

Leominster, Mrs. W. J. Wetherbee.

Lowell, Mrs. George Bowers, Miss Helen Bowers, Mr. & Mrs. C. H. French, M. H. Harrington, Mr. & Mrs. W. F. Hunt, J. E. Sullivan, Mrs. R. J. Thomas.

Malden, Mrs. F. E. Appleton, F. N. Prescott.

Marblehead, H. L. P. Wilkins, H. M. Wilkins.

Marlboro, Mrs. G. A. Stacy.

Medford, Mrs. F. W. Gow, Meriam D. Gow.

Melrose, Mrs. E. C. Brooks.

Middleboro, J. J. Pearson.

Millbrook, L. M. Peterson.

Monument Beach, Theodore Chaffin.

North Scituate, Mrs. S. A. Agnew, Miss E. A. Agnew.

Norwood, James Drommay.

Onset, Neddie Eldredge.

Oxford, Mr. & Mrs. A. M. Chaffee.

Pepperell, Mr. & Mrs. Perley J. Blake.

Pittsfield, Mrs. F. J. Wise.

Reading, Mrs. L. M. Bancroft, Mrs. A. E. Davis.

Revere, Carl G. Richmond.

Salem, W. T. Howe.

Saugus, Mrs. A. F. Hart.

Somerville, Mr. & Mrs. D. L. Dow, Mrs. Samuel Harrison, Mrs. F. E. Merrill, J. M. Towle.

Southbridge, Mrs. C. H. Abbott.

Uxbridge, W. E. Rawson.

Wakefield, Mrs. O. H. Starkweather, R. E. Starkweather, O. A. Starkweather.

Walpole, H. C. Battles.

Waltham, Mrs. Bertram Brewer,

George W. Forbush, Ella A. Moulton.
Ware, Mrs. T. E. Gleason.
Webster, S. G. Wylie.
Wellesley, Mrs. F. L. Fuller, Mrs. C. N. Taylor.
West Springfield, B. E. Fox, Mrs. T. P. Martin, Mr. & Mrs. J. F. Whitney.
Weymouth, Mrs. A. R. Taylor.
Woburn, James Hagerty.
Worcester, Florence M. Rice, Mr. & Mrs. C. I. Rice.

RHODE ISLAND.

Narragansett Pier, Mrs. Willard Kent.
Providence, L. Brightman, Robert Gray, Walter Hazelton, Mrs. G. H. Lewis, Mrs. I. S. Wood.
Woonsocket, Mrs. Z. M. Jenks.

CONNECTICUT.

Ansonia, Mrs. J. F. Davis.
Hartford, Mrs. C. M. Saville, Humphrey Sullivan.
Middletown, J. P. Bacon, Thomas Hoops, Jr., Arthur Losey, G. C. More, H. S. Warner.
Naugatuck, D. P. Mills.
New Haven, Mrs. C. M. Blair.
New London, Mrs. G. K. Crandall.
Norwich, Fannie L. MacKenzie, Mrs. S. H. MacKenzie.
Thompsonville, Mrs. H. R. Cooper, Mrs. W. P. Schwabe.
Wallingford, Mrs. J. H. Child, Marjorie F. Child, Mrs. W. A. MacKenzie.
Yalesville, Miss Mabel McKenzie.

NEW YORK.

Auburn, Mrs. J. W. Ackerman.
Brooklyn, Mrs. H. F. Yoyt, Miss Ambrose.
Johnstown, Mrs. Edgar Hodges.
New Rochelle, Mrs. M. F. Tiernan.
New York City, H. W. Ford, Mr. & Mrs. G. L. Garrison, F. Gleason, Mrs. C. L. Lincoln, M. L. Northrop, Mrs. F. W. Shepperd, Fred Shepperd, E. E. Smith, Mrs. W. H. Van Winkle, Miss E. K. Wilson, R. M. Mowry.
Rensselaer, Mr. & Mrs. R. L. Hinkley, Mr. & Mrs. S. A. Russell.
Rochester, Mrs. B. C. Little, Helen D. P. Little.
White Plains, C. P. Abbott.
Yonkers, Mrs. E. L. Peene.

NEW JERSEY.

Atlantic City, Mrs. C. Godfrey, Mrs. L. Van Gilder.
Bound Brook, Mrs. W. B. R. Mason.
East Orange, Mrs. G. W. Booth.
Perth Amboy, Mrs. Thomas Grieve.
Ridgewood, F. W. Simonds.
Salem, Mr. & Mrs. T. W. Gayner.
Trenton, Mrs. Alvin Bugbee.
Weehawken, Earle Talbot.

PENNSYLVANIA.

Berwick, M. J. Casey.
Braddock, W. H. Williams.
Pittsburg, Mrs. Morris Knowles, Mrs. F. N. Speller.

INDIANA.

Wabash, Mrs. T. W. McNannie.—301.

SUMMARY OF ATTENDANCE.

Honorary members	8
Members	171
Associates	107
Guests	301
	587

MORNING SESSION, WEDNESDAY, SEPTEMBER 13, 1916.

The convention was called to order at 10 A.M. by President William F. Sullivan, who said:

Your Honor and Ladies and Gentlemen, — The thirty-fifth annual convention of the New England Water Works Association opens under auspicious circumstances in this beautiful city, whose native air is pure and sweet; a city rich in historical and literary associations, immortalized by the poet Longfellow, and you and I may go, as he went many times, to " Deering's Woods, so fresh and fair."

Longfellow said, " A boy's will is the wind's will, and the thoughts of youth are long, long thoughts."

So, all you overworked and nerve-racked water-works men, be boys again in Portland, and instead of your will being the wind's will, let the winds of Portland be your will and waft you around the hospitable weather vane, which has been provided by our hosts, the people of Portland.

We are indeed fortunate in having this magnificent municipal building for our uses. I might say, while we are in Portland, let us remember that we are drivers of water wagons, and that the spirits of Portland's hospitality are tempered by the shade of that venerable apostle of prohibition, Neal Dow.

I cordially welcome you here, guests and members, to this our annual convention, and I know our hosts are going to cordially welcome all of us to " 'way down East." The committee of arrangements has prepared and planned an excellent program, which I know will not fail to satisfy. Headed by Mr. Johnson, it has done its work well, and I know that the committee will take care of almost our every need. Mr. Graham and the local committee have done such splendid work that we cannot fail to appreciate it. The Portland Chamber of Commerce has lived up to its reputation as a live civic body. Some boards of trade or chambers of commerce are mere names only, but here in Portland you have a living, breathing, boosting organization, which knows how to present Portland's attractions and advantages as a city to live in and to do business in. They, too, welcome us to this busy and prosperous city, and I know that when we leave it will be with regrets and a firm determination to come again.

The Committee on Exhibits has done itself proud, as you can see by looking about, and we water-works men can gain a fund of useful information by availing ourselves of the opportunity to inspect and investigate the last word in supplies and equipments which have been so generously provided by our friends, the manufacturers.

In looking over the program, you will see that it is as nearly complete as time and work can make it. The entertainment portion has not been forgotten, and those who were fortunate enough to be on the boat, last night, know that the party was pleasant and agreeable, and a proper spirit of fellowship was shown; and that is what we want in this convention, — a convention that will show warmth and a good spirit and a good-fellowship.

However, let us work while we work and play while we play, and the real serious work of this convention is that the members attend the sessions faithfully, listen to the high-grade and practical papers, and then fully and freely discuss them; for it is by this means principally that we know what is going on in the water-works world. The papers are the text-book, from the primer to the sixth reader, of our business. The discussions tell us how the other fellow does it. So let us buckle right down to business during a portion of our short eight-hour work day, so that the rest of the time we may enjoy the play which has been so generously provided for us.

Longfellow said, " Often I think of the beautiful town that is seated by the sea. Often in thought go up and down the pleasant streets of that dear old town."

That beautiful town is now the great city of Portland, the metropolis of Maine, and those " pleasant streets " are now the busy marts of trade and highways of commerce. It is our privilege and our honor to have with us to-day a man who has been selected and elected by the people of Portland as its chief magistrate, and this man is going to greet us to-day; welcome us to Portland. It gives me much pleasure to present to you the Hon. Wilford G. Chapman, mayor of Portland.

MAYOR CHAPMAN. *Mr. President, Ladies and Gentlemen of the Association,* — I am more than glad to welcome an association of experts to our city. I should perhaps appear immodest if I

should attempt to add anything to the glowing words of praise which your president has given to us. We are a city of 63 151 inhabitants, according to the United States census estimate of 1915. The Chamber of Commerce makes our population 75 000 — for purposes of its own; but the United States census will perhaps appeal as much to men of science as the returns of the Chamber of Commerce, with all due respect to my good friend Mr. Moore.

Notwithstanding some things that you may see in the organs of certain interests, it is true that the people of Maine, for the most part, use Sebago water to drink and to bathe in. Our water company here in Portland is out of politics, managed by a non-partisan commission of men who know sound business principles, and who employ only experts to administer the affairs of the company.

I regret very much that our old friend Mr. Dyer, who was one of the men, if not the man, who first turned on Sebago water in the city of Portland, who has been identified with the interests of the company from then up to the time of his death, and who has been, through it all, a loyal, useful, good man; an expert in this line of business — I regret very much that he is not here to greet and welcome many of you who I understand have been connected with him in this line. As long as the water business of Portland continues to be managed in the future as it has been in the past, for the interests of our people, there will be no politics in it. In fact, I have an idea that is what takes a thing out of politics, to manage it so well that the people are satisfied. Possibly, in the far and distant future, when the people of this community and the country are wise enough, we may take some other questions out of politics in the same way, as, for instance, the tariff and the rum question.

But enough along that line. I am more than glad to welcome this Association. I hope that our citizens will take advantage of this opportunity to learn all that they can learn about these different water appliances. This thing is true about scientific men of the present day, that they not only know themselves, but they try to make others know. That is why I am more than glad, in behalf of the citizens of Portland, to welcome a group of scien-

tific men, who know something better than any one else knows it, and who are here not only to communicate their ideas to each other, but to the people at large.

We are very glad to congratulate ourselves and congratulate the convention on the weather that we have to-day. We mean to keep a constant supply of that kind of weather for conventions. Sometimes we run short, but fortunately to-day we have got the very best weather that the world produces anywhere, with a full moon to go with it. I hope and believe you will have one of the most successful conventions in your history. I am informed that the exhibits are finer than ever before, which is the way it should be. Wherever you hold your convention, each year should be the best.

Mr. President, ladies and gentlemen of the convention, you are welcome to Portland.

President Sullivan. We have with us to-day a man who represents an office which does not require much introducing, because these officers are always able to introduce themselves, and tell us the good things of any city or community. It gives me much pleasure to call upon Mr. W. B. Moore, executive secretary of the Chamber of Commerce.

Mr. W. B. Moore. *Mr. President, your Honor, Ladies and Gentlemen,* — Unfortunately for you, I have been called in to substitute to-day for the president of our organization, who has been called from the city on account of fatal illness in his family. My remarks are going to be very brief, because this convention is a matter of business, and not talk. Your President and his Honor have said practically all of the good things about Portland, and given to you the glad hand of welcome. There has been just one fact overlooked, however, and that is in regard to the keys of the city of Portland. It is customary, as many of you know, on occasions of this kind, to state that the keys of the city are yours. Much to the credit of Portland, a great many years ago, following the time that your President referred to, a key was made in behalf of the city of Portland, to use on occasions of this kind. That key, however, was taken out one night and thrown into the waters of Casco Bay, and the town has been open to everybody since. It is open to you. We want you to come here

time and time again. We want to do everything possible to make your stay in this city one of interest, one of value, one of instructive and constructive work. If there is anything you see that is undone, tell us, and we will make it right.

Portland, as the metropolis of the state of Maine, as a distinctive city, America's sunrise gateway, as represented by the Chamber of Commerce, extends to you a glad welcome. We want to show you all the hospitality for which this city is noted, and to make your visit so nice that this will be the permanent convention place of the New England Water Works Association. I thank you.

PRESIDENT SULLIVAN. It is our pleasure to have with us today a man who represents those who have been selected to manage the water supply for this city of Portland, and for a large district hereabouts. We are, and will be, indebted during the convention to the Portland Water District for many courtesies. It gives me much pleasure to present to you William L. Blake, Esq., president of the board of trustees of the Portland Water District.

MR. WILLIAM L. BLAKE. *Mr. President, Ladies and Gentleme,* — In behalf of the Portland Water District, it gives me pleasure to join with his Honor the Mayor in welcoming you to our city. Compared with the great water-works systems of New England, the Portland Water District has perhaps very little to command your attention. As you well know, we have what is known as a gravity system. We have no important pumping system to show you and interest you. We know that this is one of the great and interesting features of many of your New England states. We have no filtration plant to maintain, and you all will feel that we are very fortunate in being able to supply Portland with an efficient water supply of such purity and character without these adjuncts.

The trustees of the Portland Water District and its employees will do everything that is possible that you may enjoy your visit here. Just a word about Lake Sebago. As you well know, we have one of the finest water supplies in the country. The lake is picturesque, and certainly none of you want to miss the entertainment that has been provided for you, and I hope that you will all, to-morrow, see that nothing stands in the way of your taking the trip. Mr. President, I thank you.

President Sullivan. On behalf of the New England Water Works Association, I sincerely thank his Honor the Mayor, Mr. Moore, and Mr. Blake, for their kind words of greeting, and I want to assure them that the New England Water Works Association esteem it a pleasure to be here, and we shall carry away with us fond recollections of Portland, and of Portland's public men.

We now have some business to transact, and, as we expect Admiral Peary here in a short time, I would like to ask our friends and guests and members to remain until he arrives. Our business may be a little dry for our guests, but I know that the Admiral's talk will be a rare treat for us all.

The Secretary read the following names of applicants for membership, all of whom had been properly endorsed and approved by the Executive Committee:

Active:

C. Godfrey, Atlantic City, N. J.
James P. Allardice, Fall River, Mass.
James Aston, Pittsburg, Pa.
Charles S. Beaudry, Lexington, Mass.
H. W. Bishop, treasurer Boothbay Harbor Water System, Boothbay Harbor, Me.
Theodore L. Bristol, president and manager of the Ansonia Water Company, Ansonia, Conn.
H. L. Elliott, superintendent Rumford Water District, Rumford, Me.
Robert Fletcher, Dartmouth College, Hanover, N. H.
Seba A. Holton, treasurer Board of Water Commissioners, Falmouth, Mass.
William J. Lambert, superintendent Public Works, Saugus, Mass.
William S. Nolan, water-works engineer and contractor, East Boston, Mass.
P. Von Weymann, Pishpek, Russia.
John Young, inspector Department of Western Canada Fire Underwriters Association, Winnipeg, Man.
Fred C. Gamewell, treasurer Palmer Water Company, Palmer, Mass.
George A. Hatfield, superintendent Sidney Water Works, Sidney, Ohio.
Howard C. Kinney, mining engineer, Waterloo, N. Y.
William E. Merck, superintendent of Water Works, Jackson, Ga.
Jean A. Clameau, town engineer, Chicoutimi, Canada.
Thurston C. Culyer, Purdy's Station, N. Y.
George E. Mann, Woodsville, N. H.
James Mullins, Springvale, Me.

Adolph Theriault, Nashua, N. H.

Ezra B. Whitman, Baltimore, Md.

Francis D. H. Lawlor, superintendent Citizen's Water Company, Bellington, Ia.

C. S. Rathburn, assistant secretary Boise Artesian Hot and Cold Water Company, Boise, Ida.

Jesse M. Worthen, M.D., superintendent Charleston Light and Water Company, Charleston, S. C.

William L. Blake, president Portland Water District, Portland, Me.

John A. Hartigan, commissioner and superintendent Longmeadow Water Company, Longmeadow, Mass.

Henry F. P. Wilkins, manager of Water Department, Marblehead, Mass.

Charles R. Preston, Lowell, Mass.

Herbert L. Hapgood, water commissioner and superintendent, Athol, Mass.

William F. Hunt, Lowell, Mass.

Maurice E. FitzGerald, superintendent of South Hadley Falls Water Works, South Hadley Falls, Mass.

Michael H. Harrington, Lowell, Mass.

Frederick H. Hapgood, Holyoke, Mass.

Earle Talbot, treasurer and general assistant superintendent Hackensack Water Company, Weehawken, N. J.

Charles E. McDonald, superintendent of water works, Waterbury, Conn.

Carl G. Richmond, superintendent of Public Works, Revere, Mass.

Associate:

Ford Meter Box Company, Wabash, Ind.

American Manganese Bronze Company, Philadelphia, Pa.

Carbic Manufacturing Company, New York City.

F. S. Eggleston, Jr., manufacturer of pneumatic and electric machinery, Roslindale, Mass.

Hartford Contractors' Supply Company, manufacturing special contractors' machinery and water-works tools, Hartford, Conn.

C. M. & H. T. Plummer, manufacturers of pipe and fittings, Portland, Me.

United Brass Manufacturing Company, Cleveland, Ohio.

Winslow & Company, Portland, Me.

Garlock Packing Company, Boston, Mass.

On motion duly made and seconded, the Secretary was empowered to cast the ballot of the Association in favor of the candidates, and, he having done so, they were declared by the President duly elected members of the Association.

President Sullivan. The meeting is now open for new business.

Mr. C. W. Sherman. On behalf of the Committee on the Dexter Brackett Memorial, I have the pleasure to submit the report of the committee, and the medal, which has been prepared for a prize, to be awarded annually for the most meritorious paper.

The report of the committee has been printed and is on file at the Secretary's office, so I will not attempt to read it, but give only the salient points at this moment. The committee sent to the entire membership of the Association, giving an opportunity to subscribe for this memorial, and received a total of $1 281.50, from 101 contributors. The expense of the committee was comparatively slight, so that after paying $1 000 to establish the medal itself, we have remaining a balance of $197.34, which we turned over to the Association with the medal. We do not suggest that this money be kept as a fund, but that it be put in with the other moneys of the Association, and that the Association assume the responsibility, from its regular funds, of striking off a medal each year for the best paper.

In accordance with our instructions, we have also drafted rules for awarding the medal, or, rather, suggested rules which should be considered and adopted by the Association. In the printed report is a list of the subscribers, and the rules which we would suggest for adoption. Such rules should not, of course, be adopted offhand and without consideration, neither should the Association bind itself at all times to an annual expense without a carefully prepared vote, and without consideration by its Executive Committee. The committee has accordingly drafted the primary resolution, which I will read:

Whereas, the Committee on Dexter Brackett Memorial has submitted its report, accompanied by the medal designed under its direction, the balance of funds collected by it amounting to one hundred ninety-seven dollars, thirty-four cents ($197.34), and a draft of rules governing the award of the Dexter Brackett Memorial medal; and whereas the said committee has recommended that, in consideration of the donation of said memorial

medal and sum of money, the Association assume in perpetuity the payment of the annual expenses connected with striking off and engraving medals and furnishing cases, which recommendation has been approved by the Executive Committee; therefore, be it resolved,

1. That the New England Water Works Association accept, and it does hereby accept, the Dexter Brackett Memorial medal and the accompanying sum of one hundred ninety-seven dollars, thirty-four cents ($197.34).

2. That, in consideration of the receipt of this medal and sum of money, the Association assume, and it does hereby assume, the obligation in perpetuity to care for the dies and to pay the annual cost of striking off and engraving medals and furnishing cases for them.

3. That the draft of rules governing the award of the Dexter Brackett Memorial medal is hereby referred to the Executive Committee for consideration and amendment or adoption, at its discretion.

4. That the report of the Committee on Dexter Brackett Memorial is hereby accepted and the committee discharged.

Before you put that resolution, I would say that I have here a proof copy of the medal, which I should be very much pleased to show to any one of the Association, and I have a cashier's check, which I will turn over.

[On motion, duly made and seconded, it was voted that the resolution be accepted and adopted as read.]

President Sullivan. You have heard the remarks of Mr. Sherman, and I know it would be well worth your while to examine the medal and to remember the man in whose honor it was gotten up.

We have with us to-day Mr. Graham, general manager of the Portland Water District, a man who has done much work to further the success of this convention. I am going to call upon him for a few remarks.

Mr. James W. Graham. *Mr. President, Ladies and Gentlemen,* — I simply want to make a few explanations in regard to the entertainment. The Fidelity Trust Company, which occupies

the tall building in the Square, extends an invitation to the members and guests to visit the building and go on the roof, where you can have an excellent view of the city, the harbor, and the mountains. If you will call at the banking department and inquire for either Mr. Weeks or Mr. Gould, they will be very pleased to take you up.

In regard to the excursion for this afternoon, we want to leave immediately after the adjournment of the morning session. I would like you to pass out the front door, where a group picture will be taken on the steps of the city building, and then we will proceed at once to the boat, five minutes' walk. A clambake will be held at Long Island, probably about one o'clock, after which the remainder of the afternoon will be spent in a sail through Casco Bay, among the islands.

For Thursday, there is a trip to Sebago Lake and Naples. The party, as you will notice from the program, is split into sections, one section going out by special train from the Union Station at one o'clock to Sebago Lake, where they will transfer to two steamers, which will be in waiting, which will take them across Sebago Lake and through the Songo River to Naples, arriving about four o'clock.

The automobile section will leave City Hall, this building, at one o'clock. Automobiles will be on the Myrtle Street side, and go by the way of Poland Springs to Naples, arriving there at four o'clock. The Rickers at Poland Springs have very kindly consented to allow us to visit the grounds, the spring, and see the manner in which they prepare their water for the market. They will have guides there to show you around. The only restriction that they have made is that if there are any children in the party, they will not be admitted to the grounds.

The Chamber of Commerce have been working very hard to secure a sufficient number of automobiles, but we find that a great many people in the city who own automobiles are at this time taking vacations, so that the cars are limited, and I would request the local members to take the trip by rail and boat, and return the same way. The trip by automobile is about forty-five miles, and over a dusty road. If there are any who prefer to go and return by the boat, we can accommodate them that

way very easily. The tickets for this excursion will be given out on the sail this afternoon.

On Friday Mr. West has arranged an entertainment for the ladies at Riverton Park, at 3.30. A special car will leave the waiting-room in Monument Square. After the adjournment on Friday afternoon, the gentlemen of the party who care to may go out to Riverton and have lunch there, or lunch here in the city and then go out afterwards. If we can get a sufficient number, the managers at the Park say that they will furnish a special dinner for us. Those who are intending to go out there for lunch will kindly leave word at the Secretary's office, in order that we may know how many to prepare for.

In the evening, there will be a short business session in the open-air theater, after which an entertainment which has been prepared by the Water District people, of local talent, assisted by some of the members of the Association.

Regarding the Saturday trip to the White Mountains, the Maine Central Railroad have very kindly given us a two-dollar rate for the round trip. The tickets will allow you, if you wish, to stop over, returning Sunday. The train leaves Saturday from the Union Station at 8.45, arriving at Fabyan's at 12.28. If you care to return that day, the return train from Fabyan's is at 5.03, arriving at Portland at 8.27. Those who desire to stay over may return Sunday at 2.30, arriving at Portland at 5.45. Dining-car service on all trains.

On motion of Mr. Stacy, duly seconded, it was voted that the President appoint a committee of five to nominate officers for the coming year.

The President subsequently appointed the following committee: Charles S. Sherman, Boston, Mass., chairman; A. W. Cuddeback, Paterson, N. J.; James Burnie, Biddeford, Me.; R. C. P. Coggeshall, New Bedford, Mass.; George Batchelder, Worcester, Mass.

Mr. Taylor. *Mr. President, Ladies and Gentlemen,* — It occurred to me this morning that perhaps it might add to the enjoyment of the members and guests to visit the new cold-storage plant which has recently been erected in Portland, and on behalf of the New England Cold Storage Company I extend

to the members and guests of the New England Water Works Association an invitation to visit that plant. If the President or officers will arange for a certain hour, I will see that there are guides or officers of the company to show you around. That hour has not been arranged for, that I know of.

President Sullivan. I know we all appreciate the kind invitation of Mr. Taylor, and I hope many members will avail themselves of the opportunity. Our invitations in Portland are coming thick and fast. I am going to call upon Mr. Graham again to say a word.

Mr. Graham. The Portland Stoneware Company, Winslow & Company, extend an invitation to the Association to visit their works and inspect their process of manufacturing sewer pipe. I think this will be very interesting to you, particularly the engineers. I think that Mr. Johnson, the chairman of the Convention Committee, has arranged for some particular hour in which this visit may be made, and it will be published in the daily water-works record, and also perhaps an announcement will be made at the meeting.

President Sullivan. The Oxford County Agricultural Society extends a cordial invitation for our body to attend the fair on any of the three days. There are special trains from Portland, September 13 and 14; one fare and free admission for our members.

I want to thank all the gentlemen for their kind invitations. Is Mr. Cole here?

Mr. Cole. At the June meeting of the American Water Works Association, a committee was appointed to confer with the committee of this Association in regard to a uniform blank to be used by the water-works associations throughout the country in compiling statistics. The report was adopted and will be printed. The sentiment that a committee of this Association should be appointed was very pronounced. It is hoped that at this meeting you will appoint a committee to work with that committee.

I move that the President appoint a committee to confer with the committee from the American Water Works Association, to prepare a uniform blank form of accounting for water consumption.

President Sullivan. Mr. Sherman, you were on the other committee. Have you anything to say on the motion?

Mr. C. W. Sherman. I don't know as there is anything to say. This Association has a committee which reported two or three years ago. Its duty was primarily to collect statistics, taking cities of different types. They presented a rather voluminous report, and went out of existence. We have no committee at the present time. It seems to me that it would be proper and desirable that we should appoint a committee to coöperate with the corresponding committee of the American Association, as Mr. Cole suggests.

[Mr. Cole's motion was put and carried.]

The President subsequently appointed the following committee: Edward S. Cole, New York, chairman; D. A. Heffernan, Milton, Mass.; Percy Sanders, Concord, N. H.; E. W. Kent, Newport, R. I.; Caleb M. Saville, Hartford, Conn.

President Sullivan. The paper, "The Water Supply of Portland," by David E. Moulton, Esq., of Portland, has been postponed until this evening, for the reason that Mr. Moulton has a number of slides showing the water supply of Portland, and Sebago Lake. It is an excellent paper, and I trust that not only the members but the ladies will attend the evening session and get a bird's-eye view of Portland's water supply.

It is many years ago since we were thrilled by the explorations and hardships of Lieutenant Peary. Again and again we followed him, year after year, in spirit as Captain Peary. Did ever a man stick to such hard and dangerous undertakings for the glory of the people of the United States? Then came the final, the superhuman dash, the climax of all modern explorations.

After that, the applause of a grateful nation, the proper recognition by the government, and we have with us to-day the man who braved the hardships, conquered the unknown, and finally planted the stars and stripes on the top of the world, Admiral Robert E. Peary.

Admiral Robert E. Peary, U.S.N. *Mr. President, Ladies, and Gentlemen of the New England Water Works Association,* — I very much appreciate your President's eloquent introduction, but the incidents of which he speaks are ancient history to-day;

but you are an organization and we a nation that is more interested in things of the present and the future than in matters of the past, so I am not going to touch this morning at all on Arctic matters, or the North Pole. The climate is very comfortable and suitable here just as it is at present.

I have very much appreciated the compliment of being asked to speak here to-day, and I have specially prized the opportunity, because it gives a chance to say two or three words to an organization made up of thinking and doing members, the type of our American citizenship, and I am going to speak to you, just briefly, on the subject which to me to-day is the most important one for this nation. It sometimes seems to me as if it were the only issue before us to-day; that is, the question of putting ourselves in the shape that is due ourselves, as one of the greatest nations and powers in the world, and putting ourselves in a shape that we *must* be in, if we expect to continue our national existence and integrity; the general subject of "Preparedness," but with special reference to what seem to me three vital fundamentals, and the three biggest items of that national preparedness. We have suggestions, we have theories, we have talk in regard to preparedness, but, in it all, it seems to me as if there are three big, broad, fundamental things which we must have, and then let the others come as accessories.

The first of those things is a fleet of sixteen thirty-five knot battle cruisers, armed with 16-inch guns; eight of those magnificent ships in the Atlantic, eight in the Pacific, complete with all accessories of torpedo boat destroyers and submarines and hydroaeroplanes; a fleet to put the navy of the United States in unquestioned second place among the navies of the world, and insure absolutely our coastal cities from continued liability to attack by the battle cruiser division of any hostile power, and, during peace, to look out for that magnificent commerce in all the seven seas of the globe which is certainly, with the solution of questions still pending abroad, coming to these United States of America. There is the first fundamental thing in my opinion, a thing pertaining to our first line of defense, the navy and the sea.

Next, we need an air service commensurate with our importance, and sufficient for our protection; a separate, independent de-

partment of aeronautics, with a seat in the President's Cabinet, independent of the army or the navy; having under its full control a comprehensive system of air coast defenses for the entire country; having under its full control a system of great aviation schools in the principal geographical divisions of the country; having under its full and undivided control the development of the possibilities, civic and commercial, of the aeroplane and of aeronautics. With the mechanical genius, with the resources, with the means of this country, under concentrated and undivided attention, such a department can be and will be eventually made one of the greatest features of our civilization, and will, in the near future, be more important for our national safety in case of trouble than our army and our navy combined.

That may seem strong language to you. Later, I am going to quote to you in corroboration of that broad statement. This is the second item, pertaining to our second line of defense of our coast, pertaining to the air.

Third, some system of universal military education and training, similar to the systems now in existence in Switzerland and in Australia, modified in some details, perhaps, to fit it particularly to our especial requirements, but some system that will educate and train every youth, every able-bodied man in the country, in military questions, and still without imposing upon the nation the enormous expense of a standing army, and without taking these youths and business men from their ordinary professions, callings, and avocations; not taking them from the prospective capabilities of the country. Switzerland is a striking example of such a system. There, with a population essentially the same as that of Massachusetts, four millions, with an area about twice that of Massachusetts, this little, commercial, particularly non-militaristic country of Switzerland at a sudden call, two years ago the first of last August, sent four hundred thousand trained citizen soldiers to her frontier, — ten per cent. of her entire population, — and, as a result of that system, and of that object lesson, Switzerland from that time until now has been an island in a raging sea of war, and has been immune from attack, aggression, or insult.

Now, what would that mean for us here? It would mean,

with a similar percentage of efficiency, that in a sudden call or emergency these United States of America could send to their defense, or have on the way to their defense in forty-eight hours, ten million trained citizen soldiers, and that very fact would be absolute insurance to us against trouble.

Perhaps the first thing that occurs to most of you is this, "What about the expenses? What about the enormous expenses of these suggested things?" Can we stand them? Do you know the equivalent of three weeks of present war cost, just to Great Britain alone, not counting in her allies; not counting in the central powers? Three weeks of present war cost, just to Great Britain alone, would give us that magnificent fleet of sixteen battle cruisers, the fastest and the most powerful in the world, with all their accessories.

Three days' present war cost, just to Great Britain alone, would give us this comprehensive coast defense system of which I shall speak a bit more in detail later; and two days of present war cost, just to Great Britain alone, would enable us to inaugurate a system of universal military training and education in this country.

How shall that expense be met? In my own personal opinion, while I am not a statesman or a financier, it seems to me that the simplest way in the world would be by a national bond issue; a bond issue to accomplish two objects, — first, to distribute that expense of insuring the national integrity between this present generation and the next, and perhaps the next; and, second, that bond issue, in small denominations, would give the small investor all through the country the safest and best possible means of investment.

In these various branches of preparedness, there is no one in which this country to-day is so woefully deficient, absolutely lacking, in fact, as in aeronautical preparedness. I have suggested — I have urged for something over a year past — a system of aero defense of our coast. The personnel and the material of that system, pending an emergency and the necessity which would demand its use in a military sense, could be utilized for life-saving purposes along our coast; for reporting ships; carrying aid to wrecks or disabled ships along our coast, but, at the same

time, it would be perfecting for us an aviation personnel, of which to-day we have nothing. That is one of the first steps to give us aeronautical preparedness, that is, a class of aviators just as numerous as our present class of chauffeurs. We need not tens, or dozens, or hundreds, but thousands of men who are capable of jumping into an aeroplane and driving it, as you drive your car. To-day we have only perhaps one or two hundred in both arms of the service, the army and the navy. I doubt if more than a hundred serviceable aeroplanes could be put in commission at this moment, and yet the army of the United States had the first aeroplane of any army in the world, and our navy had the first hydro-aeroplanes of any navy in the world. Probably there is no country in the world to-day that has the material and the personnel of such an aviation department as the United States of America, unless it may be France, and we have the advantage of France in that while the character of our material is young men, wiry, sandy, cool, courageous, the ideal type for the aviator, and the equal to the character of hers, which are recognized as the best aviators in the world to-day, we have so many more of them that we could have the finest air service in the world.

Very briefly, let me outline to you the plan of this aero coast defense system, which comprises two parts,— an aero coast patrol, which is really the picket line, and a series of squadron stations. If I can visualize to you in just a moment or two this coast patrol matter, it is this. If you will assume our coast from Eastport, Me., to Brownsville, Tex., and from San Diego up to Cape Slattery; assume those coasts divided into sections of about a hundred miles each; assume each of those sections with a coast patrol station, having two or three sturdy, heavy-weather aeroplanes, with hangars for protecting them and machine shops for repairs, aviators and mechanicians, and the like; imagine that continuous around the entire coast of the country, and that one of these hydro-aeroplanes will all the time be out on what we will call its beat, fifty miles out from the coast. We say fifty miles now. By the time the system is in operation, a year from now, the perfection of the aeroplane would be such that these aviators can be a hundred miles out from the coast, two thousand feet up in the air in clear weather; each machine carrying two persons,

the pilot and the observer; with a light wireless apparatus by which the machine can communicate with the shore, and with powerful glasses for scanning the horizon. This machine will be out from fifty to a hundred miles from the coast, two thousand feet in the air; each machine, in its section, traveling back and forth like a policeman on his city beat; the machine in the next section contiguous to it also traveling back and forth over its beat; the result being a continuous cordon or curtain of these hydro-aeroplanes around the entire country. When the system is in effective commission, the probabilities are that no ship could pass that cordon without being detected, and its presence reported to the shore by the wireless apparatus, and, if it were the case of a hostile fleet, the number and character of the ships and the probable destination reported to Washington by wireless; so that such orders as might be necessary could be sent out to the submarine flotillas, and the battleship and battle cruiser squadron and the aero-squadron. That is just the picket line, the picket line which is the modern evolution and development of that original sentinel, the cave man clad in skins, armed with a stone hatchet, crouched at the mouth of the cave that protected his family or portions of his tribe; watching for the approach of some hostile force. To-day, our picket line is the bird man, way up in the air, miles off the coast.

That is only the picket line. To make the aero defense, coast defense, complete and sufficient of itself, there is needed in addition to that the effective military, as you might say, or fighting part of the aero-defense, and that would be comprised in squadron stations at or near every one of our great coastal cities, Portland, Boston, New York, Atlantic City, abreast of Philadelphia, Fortress Monroe, Charleston, Pensacola, New Orleans, and then the same on the Pacific Coast. At or near each of these squadron stations would be one or two or three hundred aeroplanes parked, like the tents of the summer encampment of our national guard. If any such number of aeroplanes as that near our great cities seems astounding, remember that just such conditions as that are to-day in existence on the other side, and one of the reasons why Paris is not frequently visited by the Zeppelins is because there are hundreds of aeroplanes about the city, ready for instant use.

Let us see how this system of coast defense works, supposing it is in commission. Let us imagine that the hydro-aeroplane coast patrol picket line gives notice by wireless of the approach of a hostile fleet. The next step is to send out a cloud of scout aeroplanes from the squadron stations; send them out in numbers sufficient to completely overwhelm and beat down any number of aeroplanes which could be transported here upon the decks of the hostile fleet and its transports. What become the conditions then? Simply the condition of a blind man struggling with a man in the possession of his senses. The hostile force has no means of determining our strength or disposition, while we have every means of determining his strength and disposition. And next follow the great battle biplanes or triplanes which carry tons of high explosives. There are squadrons of these, and perhaps in the near future they will carry aereal torpedoes, with which to amuse the hostile fleet. Should the major portion or any considerable portion of such a fleet escape this first off-shore attack and get near enough to the coast to effect a landing, as you will recall was effected on the coast of Long Island in the naval maneuvers quite recently, then comes the next step, in which every aeroplane and every aviator in that region would be commandeered in the same way we would commandeer every automobile and every chauffeur to transport supplies or troops. Every aviator and every aeroplane would be commandeered and supplied with explosives to use at that most vital next step of the enemy, the attempt to land a party.

Now, what I have said to you in regard to numbers of aeroplanes that we need in this country probably seems, even to the best-read and best-informed among you in regard to aeronautics, as a dream, or at least something only of the remote future. As a matter of fact, it will be a reality in the near future. How many of you here this forenoon are aware of the fact, said to be true (I can't vouch for the figures in regard to matters on the other side because we do not know here as yet, and probably will not know until after the war is over), but it is said that to-day the personnel of the French air service numbers more officers and men than we have in our entire army, and that the personnel of the British air service to-day numbers more officers and men than we have in our entire

navy. There seems to be no doubt whatever but that in Germany there are from nine to ten thousand aeroplanes along the various battle fronts, and probably France has an equal number. England also has thousands, so it does not seem a very wild dream for those acquainted with the facts to imagine the time when this country will have at least two thousand aeroplanes along each of its coasts, ready for military emergency, but, pending that time, engaged in the study of our coasts and the waters off them; engaged in life-saving and perhaps the assisting of vessels in distress, and also carrying the mail. Carrying the mails is going to be one of the earliest developments of the aeroplane.

Now, just a quotation or two, to bring home to you the fact that what I have been telling you is based upon actual experience. I am going to quote to you, very briefly, the remarks of men over on the other side of the water; men who are of the highest grade of intelligence, bred to knowledge and vision; men who are in the very thick of the vital things which are happening over there; men on whose shoulders rest the safety and lives of their respective nations.

Mr. Balfour, on the floor of the House of Commons: "The time is here when command of the sea will be of no use to Great Britain without corresponding command of the air." Lord Charles Beresford, on the floor of the House of Lords: "The time is here when Great Britain's air service will be more vital to her existence than her army and her navy combined." Lord Montague: "Every first-class nation in the world immediately will be forced by that sheer necessity which knows no law, which recognizes no precedent, which fears no government, to have a separate independent department of aeronautics." General Pitame, one of the great defenders of Verdun, on the floor of the first Chamber of Deputies: "I see in the near future France with fifty thousand aeroplanes."

This matter of the aeronautical development of this country, ladies and gentlemen, has especial significance to me here to-day, in this particular place, because this coast patrol system which is moving forward and probably will become an actual fact, commenced when that system was launched in this very building, in the Mayor's office, a year ago; when the project was presented

to the Mayor of Portland, turned over by him to the Portland Chamber of Commerce, carried to a successful issue as regards the raising of funds for the establishment of one of these stations. The movement has crept along both of our coasts. Fourteen cities to-day have the funds ready to establish such stations. Some of them would have been established ere this had it not been that early last winter Senator Johnson of Maine introduced in the Senate a bill providing for an appropriation of a million and a half with which to establish that system around our entire coast, and, a week later, Representative Kearns of San Francisco introduced the same bill in the House of Representatives, and there is a practical certainty that that bill will be passed at the next session of Congress.

Believe me, gentlemen, there is to-day no more crucial question affecting both the military and the civil and commercial progress and position of the United States than a great independent department of aeronautics at Washington, to give us command of the air.

I thank you very much for your kindly attention.

President Sullivan. It is certainly interesting to know that this is the first anniversary of that history-making episode that occurred in this municipal building one year ago, and Admiral Peary certainly stated clearly and reminded us of that motto, "Safety first."

I wish to thank the Admiral, in behalf of the New England Water Works Association, for his presence here to-day. The meeting now stands adjourned.

[The meeting was then adjourned until 8 P.M.]

Evening Session, Wednesday, September 13, 1916.

The meeting was called to order at 8.15 P.M., President Sullivan in the chair.

The Secretary read an application for membership from Mr. W. H. Williams, superintendent of public works, Braddock, Pa., which had been properly endorsed and approved by the Executive Committee. On motion, the Secretary was empowered to cast the ballot of the Association in favor of the candidate, and,

he having done so, he was declared by the President duly elected as a member of the Association.

Mr. David E. Moulton read a paper on "The Water Supply of Portland," which was illustrated by stereopticon slides.

Mr. Harvey D. Eaton read a paper on "The Extension of the Water District in Maine."

Mr. L. L. Wadsworth read a paper on "The Water Supply of Madison, Anson, and Emben." These papers were discussed by Mr. Fuller and Mr. McKenzie.

A paper by Mr. E. E. Lochridge, on "The Application of Coagulant Intermittently in Excess Amounts at Springfield, Mass.," was read by Mr. Hawley, in the absence of Mr. Lochridge.

Morning Session, Thursday, September 14, 1916.

The Secretary read the applications for membership of Patrick J. Mullen, Cambridge, Mass., and Perley J. Blake, Pepperell, Mass., both of which had been properly endorsed and approved by the Executive Committee.

On motion, the Secretary was empowered to cast the ballot of the Association in favor of the candidates, and, he having done so, they were declared by the President duly elected members of the Association.

President Sullivan. The membership is growing, and we have now a membership of considerably over a thousand, but the field is still broad, and we trust that some of our members will bring in their friends, engineers of pumping stations, general foremen, registrars, men who are interested in water-works problems generally, because we believe it will be of benefit not alone to them but to us.

We have with us this morning Mr. Cummings, secretary of the Bureau of Conventions, Portland Chamber of Commerce, and I will call upon Mr. Cummings for a few words.

Mr. Cummings. *Mr. President and Gentlemen,* — I was booked to speak to-morrow instead of to-day, but the plans having been rearranged, it brought me in this morning; something that might be called a detour.

There was a Portland youth of six or seven years who had been

out with his father and mother in an automobile, and heard something about a detour. He looked at his mother and said, "Mother, I know what a detour means." She said, "What does it mean?" He said, "It means mud." We will endeavor not to make the detour of this morning mean mud, because water men naturally keep away from mud, as far as possible.

It is not necessary for me to speak in behalf of the Chamber of Commerce any word in reference to our city, of which we are so proud, because you have seen it, and can judge for yourselves. As your President told you yesterday, Portland is the birthplace of the father of Maine's prohibitory liquor law, and, naturally, we, having been brought up on water and nurtured on it, want the real article. We are somewhat fussy about the quality of our water.

A few years ago I was secretary of the board of health, an office that went along with the city clerkship. The doctors on the board naturally did most of the board of health work. We closed Saturday noon, and about one o'clock one Saturday a fellow straggled in from one of the up-country towns and said that he was looking for the board of health. I said, "The board of health office is closed, but I am secretary of the board. Anything I can do for you?" He said, "Yes. Do you know, there is a dead man in Sebago Lake." I said I wasn't aware of the fact. He said, "Yes, there is." He gave me the name, and told me when he was drowned. As you know, we get our water from Sebago Lake, and naturally I was a little interested. He said, "I know where he is." I said, "If that is true, you are an interesting character. Where is he?" He went on to tell me in nautical terms that he was so many points north by northeast of a certain point, indicating that he knew what he was talking about, and he wanted to be employed to drag for the body. I said, "We will go down and see the water commissioners; they will be interested in this." He said, "I thought the board of health would." I said, "It is, but let us start with the water commissioners." He looked up and he said, "Wouldn't the Government be interested in this?" I said, "Just why do you think the Government might be interested in it?" He said, "Wouldn't that come under the pure food law?"

I was assigned to speak on Sebago Lake, but I am not going to give any formal talk on that subject or anything else, except in this general way. As we all know, we need the coöperation of the people and of the municipality in the affairs relating to public matters, particularly in reference to water works. We are especially fortunate in Portland in having our water plant under the control of a non-partisan commission. Portland is interested, and stands back of the commission, but it is not very keen on elections. Yesterday I ran through the city clerk's record, just to see how the comparative vote was on elections on trustees. First, in 1907, when the vote came whether the city should take over the water works, a two or three million dollar proposition, — and we had 14 000 voters, — only 3 499 came out. If it had been a question of whether or not we should have three ward constables instead of four, or who should be sheriff, I have no doubt we would have got out pretty nearly all of the 14 000.

In 1908 we voted for a water trustee. The act creating the water district provided that no other subject, or no other election, should be pulled off in connection with the water district election, but our City Hall had burned then, — the old hall on this site, — and there was quite a discussion as to whether we should rebuild on the old site, or over in Lincoln Park, and what kind of a building; whether it should contain an auditorium, and a number of such questions as that. It was suggested at the time that it be put to the voters. We could not attach it to the regular water district ballot, but there was no objection, of course, to our having a special expression of the people on that point. So we had a separate ballot box in every ward room, and, as the people came up to vote for the water district trustees, they also cast in their ballots expressing their preferences on the various topics relating to City Hall. We got out 5 761 voters at that time, but it was the City Hall matter that really brought them out.

In 1910, at the election of trustees, there were 2 986 votes cast; in 1912, 3 410; in 1913, 2 226, and in 1914, 3 266, showing that Portland has confidence in its trustees; otherwise they would come out in greater numbers when it came to the matter of election.

As an illustration of coöperation, we point to our municipal

organ in the City Hall, which you will be able to hear to-morrow noon. This building was in process of construction, and Adam P. Leighton, then mayor, was at the head of the City Hall Commission. Cyrus H. K. Curtis, publisher of the *Ladies' Home Journal*, Philadelphia, who was a native-born Portland man, was here on a visit, and called on Mayor Leighton. The Mayor was showing him over the city, and took him through City Hall. As they left, Mr. Curtis said, "I would like to do something for Portland, some day." Mr. Leighton, who had been a boyhood friend, said, "Perhaps I can show you the way." After Mr. Curtis had returned home, Mr. Leighton wrote him and suggested the introduction of a municipal organ in the City Hall. Mr. Curtis wrote back that the suggestion very much appealed to him, and asked Mr. Leighton to come to New York. He did so, they consulted the builders, and Mr. Curtis gave the organ, on which nearly sixty thousand dollars has been spent. That includes the echo organ, which is hidden in the ceiling. In the programs which we will probably be able to distribute to-morrow is the description of the organ. I think some of those were sent to you with a circular letter sent out by the Chamber of Commerce. That organ is the fourth largest in the world, and is said to be the best.

It was predicted by some that it would be a white elephant on the city's hands. The city went ahead and hired a municipal organist at a salary of $5 000 a year. This organist recently had occasion to respond to a toast, and he got up and declared himself as the only municipal organist in captivity. He is a wonder; he is worth every bit of his salary. He was drawing more than that when he came on from New York. He happens to be on his vacation now, but he has kindly consented to come to-morrow and give an hour's concert, beginning at half past one.

To-morrow morning, Mme. Eames, the great singer, is to be here for a rehearsal, in preparation for some concert she is to give. She has not tried out her voice with the Portland organ. Mr. MacFarlane is to have a rehearsal with her at quarter past twelve to-morrow, and he has asked me to say that there will be no objection to anybody being in there during the rehearsal, but they want absolute quiet, from quarter past twelve for a half hour,

during the rehearsal. The public concert, to which everybody is invited, including the ladies, will be from half past one to half past two to-morrow.

In behalf of the Chamber of Commerce, I wish to endorse what was said yesterday as to our pleasure at meeting you all, and if there is any way we can serve you during your stay in Portland or any other time that you come to see us, just call on the Chamber of Commerce.

President Sullivan. All desiring to visit Winslow & Company's sewer pipe works will leave the car station at the head of Elm Street at 11 a.m. to-day. It is a very interesting place to go, to view the manufacture of sewer pipe.

Mr. Taylor cordially invites all who are interested to visit the new storage plant, one of the largest and one of the best cold-storage plants in the country. He will meet any member who wishes to go and see the plant at 11.30 in front of City Hall. To-morrow afternoon there will be tea for the ladies, at Riverton. Special cars will leave at 3 p.m. to take them down and bring them back.

All those who wish to remain down for the evening's entertainment may do so, and I wish it to be known that the committee desire that all the ladies who are going there should signify their intention, so that the members may register, and it would be a great accommodation to the committee if all who intend to stay down for the dinner, or go down for dinner to-morrow night at Riverton, would register at the Secretary's office.

[Mr. W. S. Johnson read the preliminary report of the Committee on Service Pipes, which was discussed by Messrs. Fitz-Gerald, Heffernan, Hawley, Fuller, Hastings, Martin, McKenzie, Sawyer, Dolan, Speller, Aston, Taylor, Agnew, and Weston.]

Evening Session, Thursday, September 14, 1916.

The Secretary read the application for membership of Alfred M. Chaffee, president and general manager, Oxford, Mass., which had been properly endorsed and approved by the Executive Committee. On motion, the Secretary was empowered to cast the ballot of the Association in favor of the candidate, and, he

having done so, he was declared by the President duly elected a member of the Association.

THE CHAIRMAN. The discussion on service pipes will be continued this evening, but on account of the other papers that are scheduled for this evening, and into which this discussion breaks, the total discussion on the service-pipe question will be limited to one-half hour, and individual members discussing the paper will be limited to five minutes, and will be cut off at that time.

The discussion on service pipe was resumed, being participated in by Messrs. Aston, Speller, Gear, Martin, and Raymond.

It was voted to adjourn the discussion to a later meeting.

Mr. Frank A. Barbour read a paper on " Leakage from Pipe Joints," and on motion of Mr. Sherman it was voted that Mr. Barbour's paper should be printed in the same form as the advance copies of the papers to be read at this convention, and sent to each member of the Association.

Mr. S. E. Killam, superintendent pipe lines and reservoirs, Metropolitan Water Works, Boston, Mass., read a paper entitled, " Breaks in Main Pipes," which was discussed by Mr. FitzGerald, Mr. Atwood, and Mr. Fuller.

Mr. George H. Finneran, general foreman, Water Service, Boston, Mass., read a paper on " Emergency Trucks and Repair Gangs."

FRIDAY MORNING, SEPTEMBER 15, 1916.

The meeting was called to order at 9.15. President Sullivan in the chair.

PRESIDENT SULLIVAN. Mr. Cummings, of the Portland Chamber of Commerce, is here.

MR. CUMMINGS. I have two announcements to make. One is that we would like to know as soon as we can this afternoon how many are planning to go back to New York at 8.40 to-morrow night. The Maine Central and the Boston & Maine Railroad have arranged so that they can take care of just as many as need to go, only they would like to know in advance how many there will be who need reservations. They have already put on one car, and they will put on as many more as are needed.

The other thing is, that I want to remind you again of the organ concert at 1.30 to-day. The city organist is on his vacation, but we have arranged for him to come and give a concert from 1.30 to 2.30. You are invited to come and bring the ladies.

Mme. Eames is to try out her voice with the piano and with the organ, in preparation for a concert. It is not in the nature of a recital at all; it is simply a try-out of her voice. There will be no objection to the members and the ladies being present. The only request is that there shall be absolute quiet from 12.15 on for the matter of a half hour. That will be during the lunch hour of a great many, and I suppose that is why it was selected, to make sure it will be quiet, but to the concert from 1.30 to 2.30 everybody is invited, and the more there are there the merrier.

PRESIDENT SULLIVAN. I am going to call on General Manager Graham, of the Portland Water District. I suppose you have seen him about, you all know him by this time, and you have noticed with what smoothness and efficiency everything has been running along here in Portland. He desires to make an announcement.

MR. GRAHAM. I simply want to take up a moment in regard to the entertainment. The Portland Water District automobile is at the disposal of the ladies all day. Make up a party of six, and, if you find it there, just use it. The chauffeur has been given instructions to take parties out for half or three-quarters of an hour. So keep him busy.

After the organ recital, Mr. Vernon West would like to meet the ladies who are going to Riverton, at the car waiting-station in Monument Square. A special car will be there to take them to Riverton. This evening we would like to have all the gentlemen go out there to get their dinners, and the entertainment will begin at eight o'clock. Now, don't let the weather keep you away. It looks a bit showery this morning, but should it become rainy the exercises will take place in the ball room, so that we will be all right, rain or shine. If it is pleasant, we will go out in the open-air theater. I would like you all to go out. It takes about half an hour to get there. Take any car marked "Riverton Park," down at Monument Square. The cars run every fifteen minutes.

President Sullivan. I wish to announce that immediately following this meeting there will be a meeting of the Executive Committee. I am going to call upon Mr. Sherman as a member of the committee on "Grading Water Works with Reference to Fire Protection."

The report of the committee was read by Mr. Sherman, and was discussed by Messrs. Booth, Thomas, Fuller, Hawley, Coggeshall, Macksey, and Wigmore.

Mr. A. L. Sawyer read a paper on "Some Advantages of a Classified Cash Book."

Mr. E. L. Pride, certified public accountant, read a paper on "Water-Works Accounting," which was discussed by Mr. Schwabe, Mr. McKenzie, Mr. Hawley, Mr. King, Mr. Sherman, Mr. Fuller, and Mr. Bacon.

It was moved by Mr. Sawyer that a committee on accounting be appointed. An amendment was offered by Mr. Baker that the committee should take into account the investigations made by other water-works associations. Mr. Sawyer accepted the amendment, and the motion as amended was carried.

The President subsequently appointed the following committee: Albert L. Sawyer, Haverhill, Mass., chairman; Walter P. Schwabe, Thompsonville, Conn.; Samuel H. McKenzie, Southington, Conn.; E. D. Pride, Boston, Mass.; A. R. Hathaway, Springfield, Mass.

The President announced that he had a number of invitations from different cities for the next annual convention.

President Sullivan. I shall not read these letters entirely, only go over them rapidly. Springfield, Mass., sends a cordial invitation for us to go to Springfield; the New Haven Chamber of Commerce; the Business Men's Association of Saratoga Springs, through its secretary, sends a cordial invitation; the Providence Chamber of Commerce, through its convention committee and president, sends us a cordial invitation. I have from the Holyoke Water Department a very urgent invitation supplemented by a telegram from the president of the Chamber of Commerce and the mayor.

Mr. McLean. In behalf of the City Government of Holyoke and the Board of Water Commissioners, I wish to say just a word and give you a hearty invitation to hold your convention next

year in Holyoke. You held your convention before in Holyoke, and it gave us great pleasure to entertain you to the best of our ability. Holyoke is young, growing, and what we call a model American city, with a modern water service, — we think one of the best; and a modern fire department, with modern fire houses, which we think is equal to the best; and a gas and electric department owned and controlled by the city of Holyoke, which we think is of the best. We heartily invite you to come to Holyoke next year. We have a new modern hotel that cost close to a million dollars, which is equal to accommodating all the guests and members that may come.

Holyoke is admirably situated on the Connecticut River, about halfway between here and New York, about a hundred miles from New York; very centrally located. It is a very pleasant spot, one of the garden cities of New England; near the institutions of learning of Amherst and Smith, and Mt. Holyoke is just across the river. They are great seats of learning, and at our feet is that beautiful Mt. Tom, where visitors and friends can go around and see the beautiful scenery, the charm of the Connecticut Valley. I heartily invite you, in behalf of my colleagues, our superintendent and engineers and friends, fifteen in number, who are here to attend this convention, from Holyoke, and who always come in such numbers. We always attend your conventions, and take great interest in your affairs, and we wish by our presence and our numbers to do what we can to help make the convention a success. In behalf of the mayor and my colleagues, we heartily invite you, and trust you will see your way clear to honor Holyoke by your presence next year.

President Sullivan. We heartily appreciate your kind invitation, but under the constitution the matter will be referred to the Executive Committee for action.

Mr. Gear. Upon any subject that Mr. McLean takes up, there isn't much left for anybody else to say, because he covers the ground so well. From the reception we have got here, it is plain to all of us that a city of 65 000 people can entertain us as well as New York or Boston or Philadelphia. I had a different idea of Portland before I came here. I am glad I came. I thought Portland was one of these old cities that was incorporated

about a hundred years ago; never moved very fast. I came here and found it was a " live wire " city. That is what we have got in Holyoke, a population of 65 000, and we will entertain you; everybody in Holyoke will be at the gateway to meet you. Mr. Martin will be down in Springfield to show you thé way up. You can go to the top of Mt. Tom; we will take you up on one of the best street railways of the country. You can see Springfield, Hartford, and New Haven. You don't have to go there at all; you can see them from Holyoke. Lots of you gentlemen will have a few daughters at Smith College, which is only eight miles from Holyoke. You will want to go and see the place where they will spend the next four years in college. It will be a lovely time to go there. Across the river is Mt. Holyoke. There are about seventeen hundred girls there, and about a thousand in Smith College. You can go and smile at them. At Amherst College your boys will be learning agriculture, and there is another college where they go, besides the agricultural college.

People who have traveled all over the world, up the Hudson and through Switzerland, go on the top of Mt. Tom and say that is the most beautiful spot they have ever laid eyes on. That is what we will show you. We will show you something else. If you want to come by railroad into Holyoke, we can bring you on a steam railroad that is owned by the city of Holyoke, the only city in the United States that owns a steam railroad of its own. We have seven miles of railroad, and that belongs to the city of Holyoke — leased, of course, to the New Haven. They pay us 14 per cent. forever on it, so we don't kick. That's the way we are fixed in Holyoke. Every automobile in Holyoke will be at your command while you are there. Any time you want to go, we will take you; we will guide you around one of the nicest water-works spots of its size in the country, and we can show you the cheapest water and the best drinking water. You can drink all you want of it, and they have other stuff to drink in Holyoke, too.

President Sullivan. I trust all the members will be here at the afternoon session, so we may close up the business of the convention.

[The morning session then adjourned.]

AFTERNOON SESSION, FRIDAY, SEPTEMBER 15, 1916.

The meeting was called to order at 3.10 P.M., President Sullivan in the chair.

A paper entitled, "A Suggestion that the Association Appoint a Committee to Prepare Standard Specifications for Water Meters" was read by Mr. R. J. Thomas, and was discussed by Messrs. King, Brown, and Brewer.

PRESIDENT SULLIVAN. Within a few years, different states have been creating commissions, utility commissions, and public-service commissions for regulating utilities. At first the utilities looked askance at the creation of these bodies, but I can say from what I know and what I hear from others that the companies now consider it a boon, because the commissions usually are fair and just. While they may have been created to look after the welfare of all the people, they also look out for the welfare of the utilities, in their fairness and their justice, and they give a square deal to the companies. It is our honor and our privilege to have with us to-day the chairman of the Maine Utilities Commission, Judge Cleaves.

JUDGE CLEAVES. *Mr. President and Gentlemen of the Convention,* — I want in the beginning to express my appreciation of the privilege of being here to-day, and my regret that I was unable to attend the meetings which took place yesterday and the day before. During the few minutes that you will have to bear with me, I apprehend you won't be surprised if I refrain from undertaking in any way to touch upon any of the technical, managerial, organization, or engineering features which you men are so familiar with, and concerning which I have not even a superficial knowledge. What I say to you will be along very broad lines, along the line which the President in his introduction suggested.

Between the three groups which in every New England state now are dealing not only with the commodity which you have to sell, but all other public utility commodities, a partnership exists, consisting of three members, the public, the utility, and the utility commission; and, the sooner the different members of the public and the remaining few members who are superintendents or managers of the public utilities become fully convinced of that fact, the better results will be obtained for us all. The utility commission,

or public service commission, was not intended and was not created for the sole purpose of carrying on and carrying out what was by some and at one time considered the sole benefit of the public, by reducing rates, requiring additional service, and in various ways hammering and pounding the public utilities. One of the prime objects, I believe, at the end of nearly two years' experience, and one of the fine things which the law will bring about, will be a much better understanding between your customers and you; and the public utility commission can assist, and is assisting, in gradually bringing about that better understanding. If a complaint, whether formal or informal, be made to a fairly well-informed public-service commission, the members of that commission, if they are honorable and just, feel it a duty to sit down and explain to the complainants, if they are wrong, wherein they are wrong. An individual who occupies a public position like that, to my mind, can do much more toward placating a man, or a group of men, who think they have grievances, than can the interested superintendent or manager of the particular utility which that complainant wishes to curse and swear about. So I believe that one of the principal and important functions of the public service commission, not only in New England but elsewhere, is to stand in an explanatory, fair, and decent attitude, as a sort of a bumper, not only between a group of complainants who have no real grievance, and the public utility or public service corporation which otherwise would receive first condemnation, but when, as has been the case in this state, and I assume it has been the case in other states, a special drive is attempted by some uninformed legislator against some particular public utility corporation, or some particular class of public utility corporations.

The legislature perhaps intends to do what is fair and right but, through misinformation or lack of information, may not be in a position where they can do anything that is beneficial either to the public or to the public service company. The moment that a legislature or commission does anything which unfairly and materially injures any public service company, that legislature or that commission has done something which injures the entire state in which the action takes place. That, offhand, is my belief, as a result of a somewhat brief experience.

I do not know how the matter of which I am to speak may affect all New England. I know it does not affect Massachusetts, because I take Massachusetts as sort of a test in this very brief but very important recommendation. I know that it affects the state of Maine, and I should imagine it would some of the other New England states. This organization which you have, and which embraces all New England, is splendid, but the state of Maine ought to have a separate organization, consisting of the managers and all others who are interested in a managerial capacity with our water companies. The big fellows don't need it. Take your Portland Water District here; well officered, well manned, well managed; in charge of men who are scientists in their line, who need no suggestion, no help, no encouragement. But those men cannot stop in the performance of their public duty, and in their duty as citizens, by saying "We are sufficient to ourselves; we don't need help, hence we won't help anybody else." There ought to be, and in my judgment for the success of the smaller water companies in the state of Maine must be, a state association having somewhat frequent meetings, where there can come under discussion the problems of the little fellows; the men or group of men who are perhaps running a water company which is supplying one, two, or three communities, where the aggregate of their takers may be five or six hundred consumers; five or six hundred different services. Those are the fellows that need help, and those are the communities that need help. Now, why do the communities of which I speak in the state of Maine need that kind of assistance which can come by a larger and fuller information of our managers? They need it simply because their managers get more or less discouraged, on account of the things that come up in their everyday life, their everyday business, which they don't actually know how to surmount.

It may be said that there are two ways that the law provides, in which any water company may absolutely protect and fortify its sources of supply. One is because the state gives every water company the right of eminent domain, which, of course you all understand, is the right to go out, and so far as it is necessary for the protection of the watersheds, condemn land, under certain

legal proceedings; but you have to pay for it. They don't give it to you. You have to pay them money for it. We have a law, it may be said, that makes it a penal offense for any person to knowingly or willfully pollute any pond or stream or source of supply. I sat for a good many years as a magistrate in one of the police courts in the state, and if any of you gentlemen happen to be lawyers you know how easy it would be for a good attorney to show absolutely to a court, and particularly to a jury of the county, that the ordinary pollution was neither done knowingly or willfully, because there is a vast difference, legally, between an act done knowingly and willfully and the same act, having the same result, done heedlessly or carelessly. But the pollution which goes into your water supply, and through your water system to the consumer; the pollution which comes from heedlessness and carelessness, is just as dangerous as though it was the result of a knowing or willful malperformance.

Now, in Massachusetts, the legislature has not only enacted a law, making it an offense to knowingly and willfully pollute a water supply, but it has placed in the hands of the State Department of Health very large, very important, and, to my mind, very necessary powers. The statute is as follows:

"The State Board of Health shall have the general oversight and care of all inland waters and of all streams and ponds used by any city, town or public institution or by any water or ice company in this Commonwealth as sources of water supply. The board may make rules and regulations to prevent the pollution and to secure sanitary protection of all such waters as are used as sources of water supply."

No water company or sewage company can secure legislative authority to build its system until it has secured the recommendation of the board as to the best method of protecting the existing or probable future water supplies. For us in the state of Maine, you can see how all-important that particular feature of the Massachusetts law is, that before a sewer company or a municipality, I assume, — it should be made as broad as that, — can plan and establish and put in use any sewer system, it must have the recommendation to the legislature of this board of health, or whatever particular board in the state of Maine might take

the place of that, and before the company can put in its water system, it must have the recommendation of that same authority, in order to protect not only the present and existing takers of water, but to safeguard the future. And, further:

" On petition to said board by the mayor of a city or the selectmen of a town or the president of a water company, stating that manure, excrement, garbage, sewage or any other matter pollutes or tends to pollute the waters of any stream, pond, spring or water course used by such city, town, institution or company as a source of water supply, the board shall appoint a time and place within the county where the nuisance or pollution is alleged to exist for a hearing, and after notice thereof to parties interested, and a hearing, if in its judgment the public health requires, shall by an order served upon the party causing or committing such pollution, prohibit the deposit, keeping or discharge of any such cause of pollution, and shall order him to desist therefrom, and to remove such cause of pollution."

We have had during the last year several complaints from parties against three or four and perhaps half a dozen different small water companies in the state of Maine, wherein it was alleged, and amply proven, that the supply of water that that particular company was putting into its mains and serving to the public was absolutely unfit for domestic use, and in nearly every one of these instances the company has very frankly admitted that the water being served was unfit for domestic use. It should be in every legislative charter, and if it is not in the charter, it is the duty of the water company as a matter of common decency to furnish pure water for domestic use. That is what you are for. The reason why you group together and serve the public with water instead of each man having a well is to give service. It is your duty to give good service. One of the elements of good service is serving a water that is fit for domestic use.

Some of the managers came to us and said, " What are we going to do? " I have in mind one particular instance where the municipality that was complaining through its board of selectmen as to the quality of the water, had a slaughter house within three hundred feet of the intake pipe; and not more than a thousand feet above the intake pipe of the unfiltered water there was a lumberman's camp that was used for all the things that such

a camp would be used for; and hog pens, private toilets, and all that sort of thing were being permitted by that local board of health, and still they were coming down and complaining as to the quality of the water.

In another instance, there was a stream that would have been a perfectly good stream of water, would have been all right for domestic use, had it not been for the fact that a town six or eight miles above dumped every particle of its sewage and garbage into it — a comparatively short distance above the place where the water takers of this other community were having it, unfiltered, turned into their mains and used. Well might the manager of the company say, " Yes, our water is unfit for domestic use, but for heaven's sake, what are we going to do? "

Going back to the right of eminent domain, that water company, or any of these water companies, might condemn and by paying for the land take the land adjoining the stream or the pond or whatever it is, but you who are serving some of our small country communities, way up in Maine, or Massachusetts, or anywhere else know how impossible it would be for a company whose revenue is limited, whose opportunity to broaden out is extremely limited, to pay for the watershed for that town or city of a somewhat large river, or even a substantial pond.

There are a lot of people, and I have heard some managers of water companies say, " This water analyzes all right. There is nothing absolutely dangerous to health in this water. There are no colon bacilli in it. There is nothing that would kill anybody." Somehow, I am so constituted, and I apprehend there are a good many thousand others in the state of Maine who are constituted so, that if I can go to a place where the water that I am drinking in my house comes from, and I see a hog pen, or a horse manure pile, or a garbage pile, or anything that looks like uncleanliness, I don't care whether there are three million colon bacilli to the tablespoonful of water, or whether there isn't a single one. I don't like the idea of having served to me for domestic use water that consists largely or partly of substances which drain from those places, and I apprehend the average citizen feels a good deal the same way. That is why Massachusetts — I don't know about the other states in New England — has

passed that law from which I quoted, and in which they not only refer to manure and excrement, but they speak of garbage, and all sources of pollution which in any way injure the public health.

I believe that in the state of Maine it is going to be — no, it is; the time has arrived; the clock has struck; there isn't any going to be; it is now; it is this legislature, this year, when you have got to have, not the law of eminent domain, which you can't use; not a law that says that whoever "willfully or corruptly" pollutes the source of supply of a water company, which doesn't amount to anything, but you have got to have some law, giving authority to some board, so that it or its representative can go to a place where a bad condition exists, and if it seems reasonable that that corporation or that man or that municipality or whoever it may be is needlessly maintaining something which is dangerous to health or obnoxious to the senses of the average human being, either near or within a stream which is supplying other human beings with water, the board can make the individual or the corporation remove that source of pollution and desist from future accumulation.

Somebody may ask, "Who is going to pay for this?" "The poor people are going to pay for it, and it is awful." The state will take hold of it. In Massachusetts the statute provides that an individual may be paid, if that which is necessary actually deprives him of the use of his land; the individual shall be paid, and paid by the state. The state of Maine is taxing all the people to build roads for some of the people. Under the referendum which we have recently enacted, the state is going to tax all the people to help some of the people build bridges. Almost every legislature which has met within my recollection (and it goes back further than I care to admit) has passed some special act to aid financially — and that money comes from all the people — to aid financially some small town whose bridge has been swept away by flood when the resources of the town were such, and crippled to such an extent, that it was impossible for it to build or rebuild that bridge. Now, is it any more important that all the people should aid in the building of roads; all the people should aid in the care of the insane and the poor and the mentally defective, which we are doing; in the building of bridges on a large scale, or

in the individual case of towns, than it is to take hold of this tremendously important proposition of protecting the health of all the public by aiding those companies which cannot afford to get control of watersheds by the right of eminent domain, and to give to the water takers, the people of our state, that which it is our duty to give, namely, pure water? If there is anything on the face of the earth within reason that the Public Utility Commission of the State of Maine can do to aid and assist in the passage of such a law as that, for which we feel there is the necessity, I say to you that we have the disposition to help you.

PRESIDENT SULLIVAN. You have heard the able address of the chairman of the Public Utility Commission. We agree with all his remarks but one, and that is that the "State of Maine ought to have a separate organization." We as members of the New England Water Works Association do not believe it is necessary. More effective and better results can be obtained by our larger organization. The membership of the New England Water Works Association is broader than New England. It has no Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, or Connecticut. In this day of merger and combination, some of us, at least, believe there can be better and more effective work done in an Association of this kind by having all the states represented, not alone the New England States, but the United States, Canada, and I might say the world. We have members from foreign countries. It is by numbers we are enabled to get this splendid and full rounded organization. We are able to maintain permanent headquarters. We are able to get a broad exchange of ideas, not alone from New England, but from the world, and these members from the smaller communities may join the New England Water Works Association and thus get the advantage of association with experts and water-works men of experience and men working along kindred lines.

We want the water-works men from the state of Maine to join us. We want their knowledge and their experience. We want to keep those we already have, and after this successful convention here in Portland, do you suppose we are going to allow a divorce? No, sir, not even the slightest disagreement or separation. To-day we are banded and bonded together stronger than we ever

were before, and we intend to hold tight on to every member from Maine. It may be, as time goes on, we should have a chapter or branch here in Maine. I wish to good-naturedly warn every one here that if anybody undertakes to separate the New England Water Works Association from our members "down East," there will be a real old-fashioned campaign such as this state witnessed lately and which ended last Monday. Well, I am not going to say any more about campaigns. It might be loaded. It is dangerously near politics, and we are not in politics.

However, ours is a broad line of usefulness, and we are going to hold on to our veteran member, Mr. Burnie, and others. Do you suppose we are going to lose Mr. Graham after the splendid work he has done for us,— after he has shown us what Portland is and what Portland can do,— the man who greased the ways for the New England Water Works Association to sail on Casco Bay?

It was a Portland man who wrote:

> "Thou, too, sail on, O ship of state!
> Sail on, O Union, strong and great!
> Sail on, nor fear to breast the sea!
> Our hearts, our hopes, are all with thee.
> Our hearts, our hopes, our prayers, our tears,
> Our faith triumphant o'er our fears,
> Are all with thee, — are all with thee!" —the state

of Maine.

I wish to say again, we intend to retain our members from Maine and get new ones. I sincerely believe it is of mutual advantage to our Association and the water-works interests of Maine to remain together.

MR. CLEAVES. If you give me just a moment of explanation. I surely did not mean to be understood as advocating that the water men of the state of Maine should form a separate and independent association, and not amalgamate with this splendid union, but I feel perhaps the state of Maine needs what some of us more religious ones do. We want to go to church on Sunday for the bright and nice religious things, but occasionally through the week we need to go to prayer meeting. I think the state of Maine needs a few prayer meetings.

PRESIDENT SULLIVAN. That is right, your Honor, but our

Association would like very much if the water-works men of Maine would take their religion from us.

On behalf of the New England Water Works Association, I sincerely thank Judge Cleaves for his presence and for his able address. He has reminded us that there is a fertile field for our Association in Maine, and that we must carry the gospel of water-works unity to some of our brethren down here. We must tell them about our excellent JOURNAL which publishes our transactions, papers, and addresses, and that every member receives the JOURNAL regularly; that in the small communities in the state of Maine where the water-works managers are unable to get to out Boston meetings, or even where they are unable to get to a Portland meeting, if they should join with us they would get our literature which has a fund of useful information which would be invaluable to them. I would most respectfully suggest to our honored guest that, as chairman of the Public Utilities Commission, he might do us a favor and a favor to the water-works fraternity of Maine by gently reminding the water companies that it would be a good business for some of their employees or managers to become affiliated with the New England Water Works Association and thereby keep in touch with the water-works world through our JOURNAL, which is a veritable storehouse of useful knowledge.

We have another important thing before us now, and that is, "Some Problems of New Hampshire Water Supply Sanitation," by C. D. Howard, chemist, State Board of Health of New Hampshire. I call upon Mr. Howard. After that we will have some more business, and I would like the members to remain until we get through.

[Mr. C. D. Howard read a paper, with the title as above stated.]

PRESIDENT SULLIVAN. It might be of interest to some of our members to know how our late revered associate, Mr. Walker, of Manchester, N. H., overcame some of the unsanitary surroundings on his watershed. Conditions were bad in spots on Lake Massabesic. He endeavored to have them cleaned up by suasion. Nothing doing by the owners of cottages on the islands. You know what a strong character Mr. Walker was. Well, he thought first of the health of the community, and as the owners of cottages

would neither " fish or cut bait," and as there was not sufficient law at the time to reach and correct these nuisances, he took the law into his own hands and, for the welfare of the community, he applied the torch to camps and cottages that were a menace to public health and said: " Get redress from the city of Manchester." The city settled and settled well. It was a good job well done. That is the way an unsanitary exigency was met and overcome in New Hampshire.

MR. C. W. SHERMAN. The Association is now ready to attend to its formal business, and I would like to submit a resolution of appreciation of the courtesies which have been tendered to this convention. It is, of course, a pleasure to express the sentiments of the convention as far as I can, after the generous and wholehearted manner in which we have been entertained. Nevertheless I cannot help wishing that some more eloquent member had been selected for this duty, particularly in view of the excellent character of the convention, and of the arrangements in every particular. I doubt, really, if we have a man in the Association who is ready to do justice to the theme. If you will pardon me, I will make a few preliminary remarks before submitting the formal resolution. In the first place, I want in these informal remarks to say a few things that it is hardly proper to include in a vote of thanks, since they relate to our own members, Mr. Graham and Mr. Johnson in particular, who have so ably handled this convention. I have had a little experience with work of this kind, and I know what it means to do it. Probably most of the members can do a little guessing, and perhaps if they doubled what they guessed they would not be far out of the way. It is a great pleasure to me to testify, from my knowledge of how previous conventions have been run, to the excellence of this one. The figures of attendance, of course, speak for themselves. The general attendance at the sessions of the convention speaks for the interest of the members in the sessions, and perhaps in particular also for the wisdom of selecting a place where there are not too many outside diversions or distractions. As Mr. Gear remarked this morning, it is a satisfaction to demonstrate that it is not necessary to hold conventions in Boston and NewYork in order to have them successful and well attended. As far as I

know, the only unfortunate and regrettable event in our convention is the accident to one of the automobiles on the return yesterday afternoon, when Mrs. Blake suffered a severe injury. Of course I speak the sentiment of the entire convention when I say that we regret that extremely, and I should like very much if Mr. Graham could telephone or in some other way express in our behalf to Mr. Blake and Mrs. Blake sympathy with them for the accident.

The resolution as I have written it out is as follows:

Resolved, that the thanks of the Association are hereby extended to his Honor Mayor Chapman and to the city government of Portland, for the use of the City Hall and for the many other courtesies which they have extended; to the trustees and other officers of the Portland Water District; to the Portland Chamber of Commerce; to the municipal organist, Mr. Will C. Macfarlane; to Judge Cleaves; to Admiral Robert E. Peary; to the citizens of Portland who have loaned automobiles and in other ways helped to make the convention a success; to Hiram Ricker & Son, proprietors of Poland Springs; to the Portland Stoneware Company and the New England Cold Storage Company, who extended to the convention the privilege of visiting their plant; and to the other friends and individuals who have extended so many courtesies to the Association.

President Sullivan. Before we take a vote on these resolutions, I wish to ask Mr. Graham if he will kindly convey to Mr. Blake, president of the Portland Water District trustees, our sincere regrets because of the automobile accident, and trust that Mrs. Blake will have a speedy recovery to good health.

Mr. Graham. I will do that, Mr. President.

President Sullivan. You have heard the resolution. We have certainly had a fine convention in Portland, and the Portland people have lived up to the reputation they have always had in the past. I ask all in favor of this resolution to rise.

The resolution was passed by a unanimous vote.

The Secretary read the application of Alfred M. Chaffee, Oxford, Mass., for membership, which had been properly endorsed and approved by the Executive Committee. On motion, the Secretary was empowered to cast the ballot of the Association

in favor of the candidate, and, he having done so, he was declared by the President duly elected a member of the Association.

THE PRESIDENT. There will be meetings of the Executive Committee and of the convention committee just as soon as we can get together. I trust all the members will go to Riverton Park for the final event of the convention. To-morrow, of course, some will go to the mountains, and some may not come back to Portland. However, I wish all the members in town would go out to Riverton to-night and see what Mr. Graham and our friends in Portland have done for us.

MR. GRAHAM. I would like to say a word in connection with the Riverton affair. I know the boys will be very much disappointed unless they have a good audience to-night. I trust every member who can will go there. The boys will appreciate it.

PRESIDENT SULLIVAN. A final word from Mr. Johnson before we ring down the curtain.

MR. JOHNSON. Mr. President, I don't know as I have anything to say. I have one great big feeling of gratitude all through this convention, to think how smoothly the Portland members of the committee made the thing run. I have had nothing to do but sit around and see the wheels go round. The Portland people have done it all in the very best possible way, and I am only proud that I was chairman of this committee during this convention.

The convention then adjourned.

REPORT OF COMMITTEE ON EXHIBITS, THIRTY-FIFTH ANNUAL CONVENTION.

To the President, Members, and Associates of the New England Water Works Association:

As chairman of the Committee on Exhibits for the Thirty-Fifth Annual Convention, I was fortunate in having Messrs. Harris, Thorne, and Newhall, of the Portland Water District, serve with me, and during the progress of our work had many occasions to congratulate myself on this choice.

Our first duty was to secure a satisfactory room for the exhibits, and, as the convention was to be held in the new Municipal

Building, we at once selected the main auditorium, which we obtained the use of without charge for rent or light through the efforts of the Portland Water District and the kindness of Mayor Wilford G. Chapman. Electricity for power was donated by the Cumberland County Electric Company.

Having ample room at our disposal, we next solicited exhibits, and our effort in this direction was so successful from the start that we felt justified in making somewhat extensive arrangements for the comfort and convenience of our exhibitors and the delegates who would visit them.

Our time for building and decorating the exhibitors' booths and getting the exhibits in place was very limited, but everything was ready as planned, and at five o'clock Tuesday afternoon the exhibit hall was opened to the delegates.

We did not award gold medals, but the officers, committee, and delegates decided unanimously that the following are entitled to honorable mention:

Addressograph Company, *The American City*, American Manganese Bronze Company, W. L. Blake & Company, Harold L. Bond Company, Builders Iron Foundry, A. M. Byers Company, Carbic Manufacturing Company, Central Foundry Company, The Chapman Valve Manufacturing Company, Chicago Pneumatic Tool Company, Wm. R. Conard, Cumberland County Electric Company, Joseph Dixon Crucible Company, Eddy Valve Company, Electro Bleaching Gas Company, *Engineering News*, *Engineering Record*, *Engineering and Contracting*, *Fire and Water Engineering*, Ford Meter Box Company, The Garlock Packing Company, C. Godfrey, The Goulds Manufacturing Company, The Hartford Contractors' Supply Company, Hays Manufacturing Company, James Hermeston Manufacturing Company, Hersey Manufacturing Company, The Leadite Company, Lead-Lined Iron Pipe Company, Ludlow Valve Manufacturing Company, MacBee Cement Lined Pipe Company, H. Mueller Manufacturing Company, Multiplex Manufacturing Company, National Meter Company, National Tube Company, National Water Main Cleaning Company, Neptune Meter Company, The Pitometer Company, Pittsburg Meter Company, Portland Gas Light Company, Power Equipment Company, Rensselaer Valve Company, Ross Valve Manufacturing Company, S. E. T. Valve and Hydrant Company, Simplex Valve and Meter Company, The A. P. Smith Manufacturing Company, Smith & Abbott Company, Standard Cast Iron Pipe and Foundry Company, W. P. Taylor Company, Thomson Meter Company, Union Water Meter Company, United Brass Manufacturing Company, United States Cast-Iron Pipe and Foundry Company, Warren Foundry and Machine Com-

pany, Wallace & Tiernan Company, Inc., Water Works Equipment Company, R. D. Wood & Company, Worthington Pump and Machinery Corporation, — a total of sixty exhibitors.

The committee spent \$780 in carrying on their work, all of which has been collected from the exhibitors, and there are no outstanding bills against us. In addition to the money spent by the committee, we estimate that the exhibitors' total expense was about \$20 000, for representatives' time, fares, expenses, freight on exhibits, etc.; this does not include the value of exhibits, which amounted to at least \$50 000.

We call your attention to these figures, as you will recall that the convention program covered something of importance from early morning until late in the evening, on each of the three days of the convention, and absolutely no time was set aside for inspection of exhibits. The delegates were anxious to inspect the exhibits, and, as the exhibitors had the best men on their sales forces on hand to meet them, we feel that the Association should set aside at least a day or two, at future conventions, for this purpose, if the exhibits are to be continued as a part of the convention.

In concluding, I wish to thank the exhibitors, whose combined efforts resulted in one of the largest and finest displays of waterworks goods ever made; my associates on the Exhibit Committee, without whose valuable assistance my task would have been impossible; Mr. Fred M. Prescott, the contractor for the booths and decorations, who did more for us than his contract called for; and last but not least, the employees of the Portland Water District, who did the assembling and arranging of exhibits.

WM. F. WOODBURN, *Chairman.*

November Meeting.

Hotel Brunswick, Boston, Mass.,
November 8, 1916.

The President, Mr. William F. Sullivan, in the chair.
The following members and guests were present:

Honorary Members.

R. C. P. Coggeshall.
A. S. Glover.
F. E. Hall.
R. J. Thomas. — 4.

Members.

D. L. Agnew.
S. A. Agnew.
L. M. Bancroft.
F. A. Barbour.
G. W. Batchelder.
A. E. Blackmer.
J. W. Blackmer.
James Burnie.
George Cassell.
J. E. Conley.
J. H. Cook.
John Cullen.
L. R. Dunn.
F. L. Fuller.
Patrick Gear.
F. J. Gifford.
H. J. Goodale.
C. R. Gow.
J. W. Braham.
F. M. Griswold.
R. K. Hale.
A. R. Hathaway.
Allen Hazen.
D. A. Heffernan.
C. R. Hildred.
J. L. Howard.
A. C. Howes.
S. A. Holton.
W. F. Hunt.
W. F. Howland.
W. S. Johnson.
Willard Kent.
S. E. Killam.
G. A. King.
John Knickerbacker.
W. J. Lumbert.
P. J. Lucey.
H. V. Macksey.
A. E. Martin.
W. E. Maybury.
John Mayo.
F. E. Merrill.
M. L. Miller.
William Naylor.
C. E. Peirce.
T. A. Peirce.
H. E. Perry.
H. G. Pillsbury.
P. R. Sanders.
C. M. Saville.
A. L. Sawyer.
J. E. Sheldon.
C. W. Sherman.
E. C. Sherman.
Sidney Smith.
G. H. Snell.
G. A. Stowers.
W. F. Sullivan.
J. L. Tighe.
E. J. Titcomb.
D. N. Tower.
W. H. Vaughn.
R. S. Weston.
H. L. Whitney.
F. B. Wilkins.
G. E. Winslow.
M. B. Wright.
L. C. Wright.
C. R. Preston. — 69.

Associates.

Harold L. Bond Co., F. M. Bates, G. S. Hedge.
Builders Iron Foundry, F. N. Connet, A. B. Coulters.
Darling Pump & Mfg. Co. (Limited), H. A. Snyder.
Chicago Pneumatic Tool Co., T. S. Eggleston, Jr.
Engineering News, N. C. Rockwood.
Hayes Machinery Co., F. H. Hayes.
Hersey Mfg. Co., A. S. Glover, J. H. Smith.
Garlock Packing Co., C. D. Allen.
Lead Lined Iron Pipe Co., T. E. Dwyer.
Ludlow Valve Mfg. Co., A. R. Taylor.
MacBee Cement Lined Pipe Co., J. D. MacBride.

H. Mueller Mfg. Co., G. A. Caldwell.
National Meter Co., J. G. Lufkin.
Neptune Meter Co., H. H. Kinsey.
Pittsburgh Meter Co., J. W. Turner.
Rensselaer Valve Co., F. S. Bates, C. L. Brown.
A. P. Smith Mfg. Co., F. L. Northrop.
Standard Cast Iron Pipe & Foundry Co., W. F. Woodburn.
Thomson Meter Co., E. M. Shedd.
Union Water Meter Co., F. E. Hall.
R. D. Wood & Co., H. M. Simons.
Henry R. Worthington, Samuel Harrison, E. P. Howard. — 27.

GUESTS.

A. H. Howard, New York, N. Y.
F. N. Prescott, Boston, Mass.
H. K. Prescott, Waterford, N. Y.
P. E. Gear, Boston, Mass.
Mr. Dennett, Boston, Mass. — 5.

The Secretary presented applications, properly endorsed and recommended by the Executive Committee, from the following named persons:

For Resident Membership.

Alexander Bresth, Boston, Mass., assistant engineer State Department of Health of Massachusetts.

Timothy E. Hopkins, Danielson, Conn., president Crystal Water Co., Danielson, Conn.

W. D. Van Brunt, Southampton, Long Island, N. Y., president of Southampton Water Works.

Hiram Plattner, North Attleboro, Mass., superintendent and engineer North Attleboro Water Department.

Morton B. Wright, North Chelmsford, Mass., superintendent North Chelmsford Fire District.

For Non-Resident Membership.

Charles F. Attersall, Winchester, Ky., superintendent Water Works.

H. F. Dunham, New York City, civil and hydraulic engineer.

H. E. Wolbert, Mt. Vernon, N. Y., superintendent New York Inter-Urban Water Co., Mt. Vernon.

On motion of Mr. Fuller, the Secretary was instructed to cast one ballot in favor of the admission to membership of the gentlemen whose names had been read, and, the Secretary having done so, they were declared elected members of the Association.

MR. W. S. JOHNSON. *Mr. President and Gentlemen,* — Two months ago in the city of Portland the New England Water Works Association held one of the most successful conventions in its history. Towards the success of the convention many things contributed: the beautiful city and its surroundings, the wonderful weather, the splendid work of our members from Portland and

vicinity, and especially the wonderfully attractive and interesting exhibit of water-works appliances which far excelled anything of the kind which has ever been shown in this country. It is upon this last feature of the convention that I wish to say a few words.

The Convention Committee, to whom fell the task of appointing an Exhibit Committee, fully realized that the exhibit of water-works appliances was one of the most important features of our conventions, and it realized, too, that without a great amount of intelligent work on the part of some one man, the exhibit would be a failure. We naturally turned first to the man who had so successfully engineered many previous exhibits, Mr. William F. Woodburn.

Mr. Woodburn felt, and with good reason, that he had done his share, but he was finally prevailed upon to try once more, and with his customary energy he started in to prepare an exhibit which would eclipse all others. I personally know something of the great amount of work he put in during the summer, having repeatedly found him at his office surrounded by diagrams of space, lists of possible exhibitors, and correspondence. Then for a week previous to the convention he was at Portland with his coat off, and his sleeves rolled up, doing three men's work. A paper of tacks is wanted; ask Billy Woodburn. An expressman comes in with a package; see Billy Woodburn. A dispute arises between two exhibitors about some space; Woodburn is the man who settles it all, at the same time putting salve on the wounds so that both men go away feeling that they have been used just about right. And all the time he preserves that good-natured smile on his face, — a smile that is worn, not a mask, but which extends well inside his ample frame.

Mr. Woodburn, I have been asked by the exhibitors at the Portland convention to say a few words to you for them, but I want, first, to take the opportunity to thank you on behalf of the Convention Committee, realizing, as we do, the efficient work which you did, and how much your work contributed to the success of the convention. Now, for the exhibitors at the convention I take great pleasure in presenting you this Masonic charm and chain as a token of their appreciation of your indefatigable energy,

your self-sacrificing helpfulness, your eminent fairness, and your unfailing good nature. And for the rest of the Association, while our expression may not take so substantial a form, I want to assure you that you have the thanks of all members, individually and collectively, and their best wishes for your continued prosperity.

MR. WOODBURN. *Mr. President, Mr. Chairman, and my friends,* — I hardly know what to say. I felt that the many kind words and expressions of appreciation that I heard at Portland on the outcome of our preparation for the exhibitors was more than any man should expect. Every one seemed to be pleased, and that was all I wanted. We did have a little work to do getting ready, but there was always something to it that made it very pleasant. Hearing from a good many old friends in the letters they wrote in reply to my letters and my circulars brought me in contact with them again and naturally rekindled the spark of old friendship. I hardly expected to be rewarded with such a beautiful gift. It is something I have had in mind presenting to myself for some time. I thank you all and regret that I cannot express my thanks in such felicitous language as our chairman has used in presenting this to me.

THE PRESIDENT. This is a very pleasing echo of our Portland convention, to the success of which Mr. Woodburn contributed so largely.

Mr. F. A. Barbour, C.E., of Boston, Mass., spoke upon "Leakage from Pipe Joints," which was the subject of a paper presented by him at the Portland convention. The paper was also discussed by Mr. D. A. Heffernan and Mr. Charles W. Sherman.

Mr. Allen Hazen presented the report of the Committee on Meter Rates, Water Loss by Leakage, Non-Registration of Meters or Otherwise.

On motion of Charles W. Sherman, it was voted to accept the report of the Committee on Meter Rates and adopt its recommendations.

Mr. S. A. Agnew, superintendent of the Scituate Water Company, Scituate, Mass., gave an interesting talk on "San Domingo," illustrated by stereopticon views.

Adjourned.

EXECUTIVE COMMITTEE.

Meeting of the Executive Committee of the New England Water Works Association at City Hall, Portland, September 13, 1916.

Present: President William F. Sullivan, and members Caleb M. Saville, Samuel E. Killam, D. A. Heffernan, Robert J. Thomas, Lewis M. Bancroft, George A. King, and Willard Kent.

Forty-one applications for active membership and ten for Associate membership were received and recommended therefor, viz., —

Members.

James P. Allardice, civil engineer, Fall River, Mass.
James Aston, metallurgical engineer, Pittsburgh, Pa.
Charles S. Beaudry, Lexington, Mass.
Clarence A. Bingham, general manager Water Works, Norwood, Mass.
H. W. Bishop, treasurer Boothbay Harbor Water Works, Boothbay Harbor, Me.
Perley J. Blake, superintendent Water Department, Pepperell, Mass.
Theodore L. Bristol, president and manager Water Co., Ansonia, Conn.
A. M. Chaffee, president and general manager Water Co., Oxford, Me.
Jean A. Claman, town engineer, Chicoutimi, Quebec, Canada.
Thurston C. Culyer, engineer in charge Watershed Division, Department Water Supply, Gas and Electricity, City of New York, Purdy's Station (Westchester County), N. Y.
H. L. Elliott, superintendent Rumford & Mexico Water District, Rumford, Me.
Maurice E. Fitzgerald, superintendent South Hadley Falls Water Works, South Hadley, Mass.
Robert Fletcher, president N. H. State Board of Health, Dartmouth College, Hanover, N. H.
Fred C. Gamwell, treasurer Palmer Water Co., Palmer, Mass.
Frederic H. Hapgood, assistant engineer to J. L. Tighe, consulting engineer, Holyoke, Mass.
Herbert L. Hapgood, superintendent Water Works, Athol, Mass.
John W. Hartigan, superintendent Water Works, Longmeadow, Mass.
George A. Hatfield, superintendent Water Works, Sidney, Ohio.
Seba A. Holton, treasurer Board of Water Commissioners, Falmouth, Mass.
Michael H. Harrington, foreman Lowell Water Department, Lowell, Mass.
William F. Hunt, foreman Lowell Water Department, Lowell, Mass.
Howard C. Kinney, superintendent Water Works, Waterloo, N. Y.

Francis D. H. Lawlor, superintendent Citizens Water Co., Burlington, Ia.
William J. Lumbert, superintendent Public Works, Saugus, Mass.
George E. Mann, foreman Woodsville Aqueduct Co., Woodsville, N. H.
William E. Merck, superintendent Water Works, Jackson, Ga.
James Mullins, superintendent Water Works, Springvale, Me.
Patrick T. Mullin, Cambridge Water Works, Cambridge, Mass.
Charles E. McDonald, superintendent Water Works, Waterbury, Conn.
William S. Nolan, civil engineer, East Boston, Mass.
Charles R. Preston, assistant engineer, City Hall, Lowell, Mass.
C. S. Rathbun, assistant secretary Boise Artesian Hot and Cold Water Co., Boise, Ida.
Carl G. Richmond, superintendent Public Works, Revere, Mass.
Adolph D. Theriault, general foreman Pennichuck Water Works, Nashua, N. H.
Earle Talbot, treasurer and assistant superintendent Hackensack Water Co., Weehawken, N. J.
P. Von Weymarn, assistant chief engineer, Reclamation Department, Pishpek, Russia (in Asia).
Ezra B. Whitman, consulting engineer, Baltimore, Md.
Henry F. P. Wilkins, manager Water Department, Marblehead, Mass.
W. H. Williams, superintendent Public Works, Braddock, Pa.
Jesse M. Worthen, M.D., superintendent Charleston Light and Water Co., Charleston, S. C.
John Young, inspector, Sprinklered Risk Department, Western Canada Fire Underwriters Association, Winnipeg, Man.

Associates.

American Manganese Bronze Co., Holmesburg, Pa.
William L. Blake, Portland, Me.
Carbic Mfg. Co., New York City, N. Y.
Chicago Pneumatic Tool Co., Boston, Mass.
Ford Meter Box Co., Wabash, Ind.
C. Godfrey, Atlantic City, N. J.
The Hartford Contractors' Supply Co., Hartford, Conn.
C. M. & H. T. Plummer, Portland, Me.
United Brass Mfg. Co., Cleveland, Ohio.
Winslow & Company, Portland, Me.

One application for reinstatement was received, and it was unanimously voted that the applicant be and hereby is reinstated to membership on his compliance with the requirements of the constitution.

Mr. Charles W. Sherman, for the Committee on Dexter Brackett Memorial, presented the report of that committee with accom-

panying resolution, which is, by unanimous vote, recommended for adoption by the Association.

Mr. Caleb M. Saville, of the Committee on a National Water Law, reports recommending that the said committee be authorized and empowered to confer, participate, and join with committees from other bodies having a like purpose in view, and it was, by unanimous vote, so authorized.

WILLARD KENT, *Secretary.*

Meeting of the Executive Committee of the New England Water Works Association at headquarters, Tremont Temple, Boston, November 8, 1916, at eleven o'clock A.M.

Present: William F. Sullivan, President; Caleb M. Saville, Samuel E. Killam, R. C. P. Coggeshall, F. J. Gifford, Richard K. Hale, Lewis M. Bancroft, George A. King, and Willard Kent.

Eight applications for membership were received, as follows:

Members.

Alexander Bresth, assistant engineer, Massachusetts State Department of Health, Boston, Mass.

William Plattner, superintendent and engineer Water Department, North Attleboro, Mass.

Morton B. Wright, superintendent North Chelmsford Fire District, North Chelmsford, Mass.

Timothy E. Hopkins, president Crystal Water Co., Danielson, Conn.

H. E. Wolbert, superintendent New York Inter-Urban Water Co., Mount Vernon, N. Y.

W. D. Van Brunt, president Southampton Water Works, Southampton, Long Island, N. Y.

H. F. Dunham, civil and hydraulic engineer, New York, N. Y.

Chas. F. Attersall, superintendent Water Works, Winchester, Ky.

And were by unanimous vote recommended therefor.

The proposal of the National Tube Company to exhibit to the Association motion pictures of the manufacture of pipe was, after discussion, laid on the table subject to investigation by the Secretary.

A communication from Mr. F. H. Newell, chairman of Committee on Engineering Coöperation, with reference to the Third Con-

ference of Engineering Societies, was referred to Mr. John W. Alvord, of Chicago, Ill.

The subject of increasing the amount of advertising in the JOURNAL of the Association was discussed, and it was suggested that the members of the Executive Committee make individual effort to accomplish that result.

Mr. S. E. Killam, of the committee on furnishing office at headquarters, reports progress, and it was unanimously voted that the whole question of furnishing be left with the committee, with full power to act.

Voted, that a committee, consisting of the President, the Treasurer, the Advertising Agent, the Editor, and three additional members, to be appointed by the President from the membership residing near Boston, should consider the question of finances and report at the next meeting of the Executive Committee.

Adjourned.

Attest:

WILLARD KENT, *Secretary.*

INDEX OF ADVERTISERS.

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"KEYSTONE" WATER METER

"EUREKA" WATER METER

MUELLER
WATER TAPPING MACHINES

Mueller No. 2 Machine

Has your Company a MUELLER machine?

If not—why?

There isn't a better investment in the Water Works line.

One machine will last from 20 to 30 years; and with a very low cost of maintenance.

MUELLER machines are simple, efficient and convenient.

Every machine is Unconditionally Guaranteed.

Write us to-day for our booklet on tapping machines, and our liberal exchange proposition on your old machine, if you have one. Over 90% of the tapping machines in use in the United States are MUELLER machines.

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DECATUR, ILL.

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INDEX OF ADVERTISERS. (*Continued*).

CLASSIFIED DIRECTORY OF ADVERTISEMENTS.

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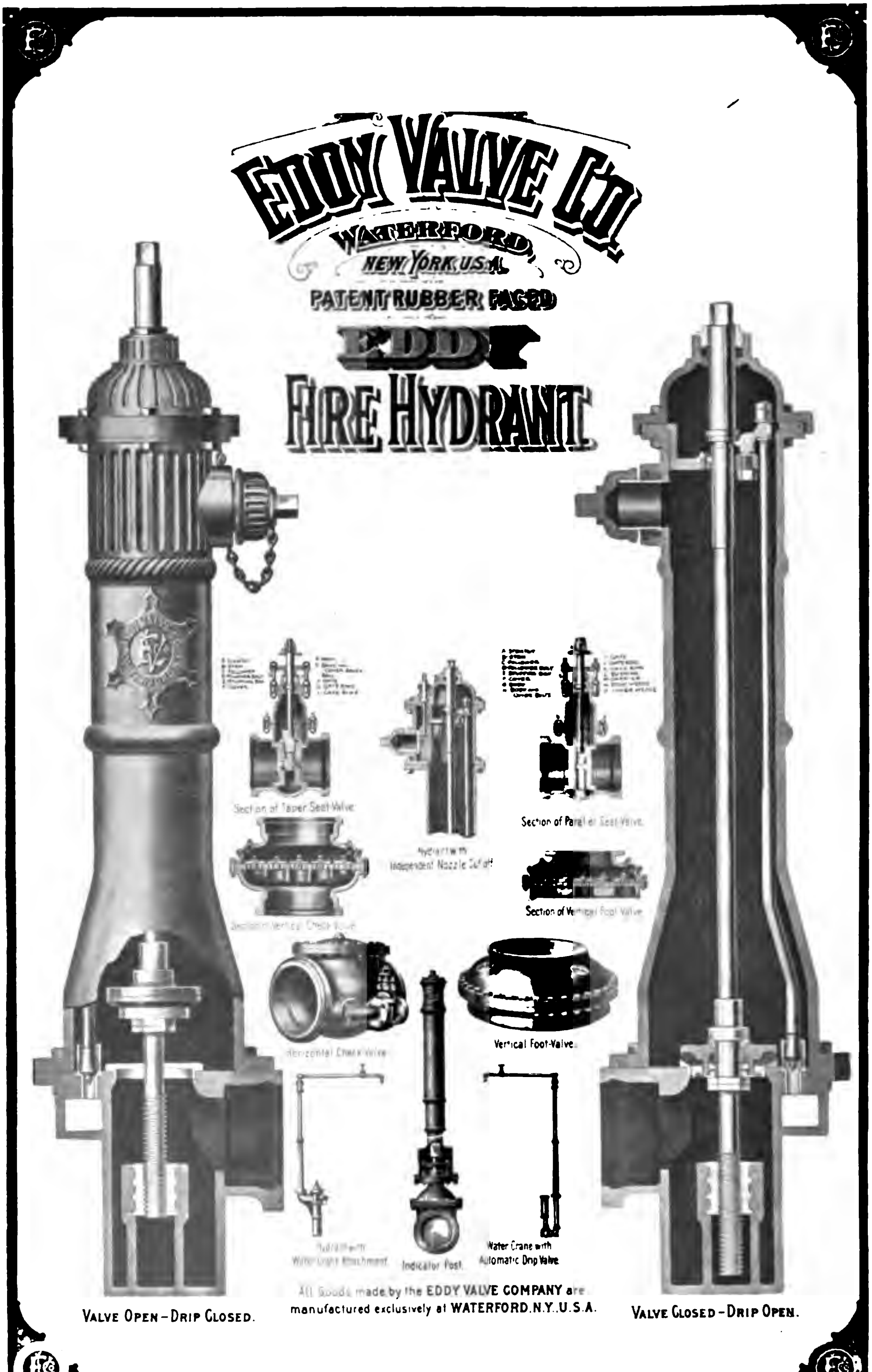
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CLASSIFIED DIRECTORY OF ADVERTISEMENTS (*Continued*).

Index continued on page xxix.)

CLASSIFIED DIRECTORY OF ADVERTISEMENTS (*Concluded*).

NOTICE.

The copies of the September, 1914, Journal have been entirely disposed of. Members who are willing to dispose of their copies will kindly mail them to the Secretary who will pay 75 cents a copy for a limited number. The following Journals are also wanted to make up sets: June, September and December, 1887; September, 1888; June, 1893; March and September, 1899; and September, 1905.

New Members!

Order your certificate of membership and the Association button Now.

New England Water Works Association,

ORGANIZED JUNE 12, 1882.

APPLICATION FOR MEMBERSHIP.

I, the undersigned, residing at ....

.... *being desirous of admission into the New England Water Works Association, hereby make application for* ....
(*resident, non-resident or associate*)
.... *membership.*

I am .... *years of age, and I have been engaged in the following named work:*

....

....

....

I will conform to the requirements of membership if elected.

Signed, ...

Address, ...

Dated, ... *191*

Resident members are those residing in New England; all others are non-resident
Entrance fee is $5.00 for resident and $3.00 for non-resident members.
Annual dues are $3.00 for both resident and non-resident members.

Endorsed by

....

....

Members N. E. W. W. Association.

SAMUEL USHER
BOSTON